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***Eupteryx petasitidis* Ferrari, 1882 (Auchenorrhyncha Cicadellidae)**. The taxon from Piedmont has been described as *Eupteryx carpini petasitidis*. Later, it was considered a synonym of *E. atropunctata* (Goeze, 1778). Recently (2014), *E. petasitidis* was re-established as a valid species based on a detailed study of coloration and genital morphology. Until now, this species has been found only in the Italian mainland (from Piedmont to Calabria).

Apparently, it is monophagous and lives on *Petasites hybridus* (L.) Gaertn., Mey. and Scherb., and has been found only in rather low altitudes (100 - 800 m) on their host plant in shadowy places near rivers or brooks. Its closest relatives are *E. atropunctata* (Goeze, 1778) and *E. aurata* (Linnaeus, 1758), which both are polyphagous with a wide range of host plants and present in many European countries.

Christoph Bückle. Neckarhalde 48, D-72070 Tübingen, Germany; e-mail: rosaurusrex@gmx.de (photos by G. Kunz)

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Observations on some Staphylinids (Coleoptera). 286° contribution to the knowlewdge of the Staphylinidae

Arnaldo Bordoni

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ABSTRACT Holotype depositories of some species of Afrotropical Xantholinini are listed and a new name is proposed for *Thyreocephalus mirabilis* Bordoni, 2016.

KEY WORDS Staphylinids; taxonomy; conservation.

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In the recent revision of the Afrotropical Xantholinini (Bordoni, 2016) some parts of the text concerning four species were deleted accidentally. In this short note I provide the missing data related to these species.

Pag. 586, to *Alexyrea pholeophila*, Bordoni, 2016, the holotype is preserved in MRAC, Musée royal de l'Afrique Centrale, Tervuren (Belgium); the following specimens from the same locality of the holotype and the specimens cited from Tanzania, Terr. Mt Meru etc., are paratypes.

Pag. 666, to *Metocinus afromontanus* Bordoni, 2016, the holotype is preserved in MRAC, Musée royal de l'Afrique Centrale, Tervuren (Belgium).

Pag. 690, to *Metocinus rhodesianus* Bordoni, 2016, the holotype is preserved in MRAC, Musée royal de l'Afrique Centrale, Tervuren (Belgium); the following specimens from the same locality of the holotype are paratypes.

Pag. 691, to *Metocinus fimbriatus* Bordoni, 2016, the holotype is preserved in MRAC, Musée royal de l'Afrique Centrale, Tervuren (Belgium); the following specimens from the same locality of the holotype are paratypes.

Pag. 541, *Thyreocephalus mirabilis* Bordoni, 2016, from Sierra Leone is a junior secondary homonym of *T. mirabilis* (Jarrige, 1948) from Madagascar. *Thyreocephalus leonensis* nom. nov. is therefore proposed as a replacement name for *T. mirabilis* Bordoni 2016: 541.

Etymology: the specific epithet refers to Sierra Leone.

ACKNOWLEDGEMENTS

Thanks to Alfred Newton (Field Museum of Natural History, Chicago, USA).

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Feeding habits and condition of the seabream *Sparus aurata* Linnaeus, 1758 (Perciformes Sparidae) in the gulfs of Skikda and Annaba (Northeast of Algeria)

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ABSTRACT The Feeding habits of the royal seabream *Sparus aurata* Linnaeus, 1758 (Perciformes Sparidae) in the northeast of Algeria were continuously monitored from April 2013 to May 2014. A study was carried out on the digestive content of 380 specimens, with a total length ranging between 18.1 cm and 48 cm. Overall, 1615 preys belonging to ten different phyla (Chordata, Echinodermata, Crustacea, Chlorophyta, Mollusca, Annelida, Bryozoa, Platyhelmintha, Nemathelmintha, Tallophyta), were computed. The reoyal seabream *S. aurata* has a widely varied diet. At a juvenile stage it is omnivorous, feeding on different benthic preys (i.e. shellfishes, molluscs, annelids, plants), on pelagic ones (fishes, eggs and Copepods), and Chlorophycea algae, as well. On a further stage, it shows a predatory feeding behavior, with molluscs constituting its preferential food as shown by the Main food index (MFI) values.

KEY WORDS Algeria; Diet; preferential food; Sparidae; *Sparus aurata*.

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INTRODUCTION

The seabream *Sparus aurata* Linnaeus, 1758 (Perciformes Sparidae) is a marine fish species of a considerable commercial value, particularly appreciated all over the Mediterranean Sea, however its fishing has decreased throughout the years for many reasons (Wiefels, 2014). On the other hand, the growing trend of the aquacultural production reveals an increasing renewed interest for this species (Wiefels, 2014).

This study aims at broadening the acquired knowledge about this species' way of feeding in the gulf of Annaba with additional further data related to the gulf of Skikda, by analyzing the food spectrum in both areas by means of qualitative and quantitative methods.

MATERIAL AND METHODS

Fish sampling

The study deals with 380 individuals, whose length ranges between 17 cm and 48 cm, with a variable weight from 65 g to 1440 g. We removed and preserved the whole digestive tract in a 98% ethanol within a hermetic pill container. Fishing was carried out monthly by professional fisheries and the samples were taken in the gulfs of Annaba

(36°52'34"N, 6°54'33"E) and Skikda (Latitude of 36°53'59"N, 7°46'00"E).

Stomach content analysis

The digestive tract of the specimens was examined under A binocular magnifier (10x) to sort different taxa. The ingested preys were identified and classified, when possible, then counted and weighed with a Kern 770 balance (precision: 10^{-4} g). Preys were classified according to the morphological criteria for each species. Quantitative analysis was carried out to show the numerical importance of ingested items, in function of sex and different seasons. Several food indices, including Vacuity index (VI %), frequency of occurrence (Fo%), and numerical percentage of prey (N %) were computed with respect to the entire population and, in addition, to both sex (Hureau, 1970) and seasons (Berg, 1979). The mean values of the VI were subjected to statistical comparison using t-Student and Chi-square (χ^2) tests. Comparisons were realized by MINITAB (Inc, 2016) and XLSTAT (Microsoft, 2016) softwares. The various preys were classified according to their preponderance (frequency, number, weight) using the Main Food Index values "MFI" (Hand Food Index) (Zander, 1982). Spearman's coefficient of rank correlation (ρ), (Lebart et al., 1982), was used to analyze the variation of Feeding habits, statistically. The statistical significance of ρ was assessed through the Student distribution with n=2 degrees of freedom (Dagnelie, 1975).

RESULTS

Out of 380 examined fishes, 245 had full stomachs, corresponding to a mean annual vacuity index of 35.21%. Their increase starts from minimal value to higher amounts in November (65.63%), and January (81.82%) (Fig. 1). From February to June, it ranges between 13.33% and 5.88%.

Overall, the diet of seabream in the eastern coast of Algeria consists in 10 taxa (Table 1). 1615 preys were identified on a total mass of 1606.35 g with an average number of biomass, by each full stomach, of 5 ± 3.4 preys of 2.03 g each. Within these ten taxa, the shellfishes are best represented.

The identification made on the level of genus and species, showed the following species:

Parapenaeus longirostris (Lucas, 1847) (Decapoda Peneidae); *Pecten maximus* Linnaeus, 1758 (Bivalvia Pectinidae) and *Bothriocephaleus claviceps* (Goeze, 1782) (Cestoda Bothriocephalidae),

Items	Ni (%)	Pi (%)	Fo (%)	MFI
Crustacea	10.15	9.05	17.8	11.25
Amphipoda	0.87	0.29	2.86	0.739
Isopoda	0.06	0	0.22	0.004
Decapoda	9.23	8.76	14.73	10.24
Parapenaeus longirostris	0.37	0.39	0.88	0.495
Brachyura	1.18	3.99	2.2	2.2
Anomura	2.66	1.06	1.54	1.494
Decapoda Natantia	0.06	0	0.22	0.008
Decapoda pink	0.06	0	0.22	0.025
shellfish inferior cirriped	0.12	0	0.44	0.023
Echinodermata	0.19	0.29	0.66	0.347
Mollusca	61.36	59.12	28.13	51.436
Cephalopoda	0.25	0.11	0.44	0.19
Sepiidae	0.19	0.01	0.22	0.034
Cephalopoda	0.06	0.1	0.22	0.118
Gasteropoda	37.96	29.94	18.02	28.947
Lamellaridae	0.87	0.02	0.22	0.093
Turritellidae	7.74	28.95	10.99	16.466
Gasteropoda	29.35	0.97	6.81	4.182
Bivalvia	23.16	29.08	9.67	0.127
Flat Oyster	0.25	0.03	0.22	0.09
Bivalvia	22.72	28.95	9.01	21.434
Pecten maximus	0.06	0	0.22	0.011
Chordata	14.24	26.17	27.25	23.303
Osteichthyes	12.2	22.39	21.98	19.561
Clupeidea	2.04	3.78	5.27	3.72
Eumetazoa	11.39	3.23	16.04	6.66
Annelida	3.03	0.48	7.47	1.589
Bryozoa	0.06	0	0.22	0.018
Platelminta	7.86	2.73	8.13	4.669
Nematelminta	0,43	0,02	0,22	0,09
Macrophyta	0.19	0.13	0.66	0.232
Tallophyta	2.17	1.01	7.25	2.181
Algal Remains	0.06	0.1	0.22	0.118
Total	**455**	**1615**	**1606.35**	

Table 1. *Sparus aurata*'s food composition,in Skikda and Annaba Gulfs. Ingested preys classification according to the degree of importance by MFI: 'Main food index'. Fo: Prey's frequency of occurrence (items). Ni: Prey's numerical percentage (items). Pi: Prey's percentage by weight (items).

while the remaining preys' classification based on species and genus was impossible because of the advanced degree of digestion. The Chordata were represented as well, noticeably on the individuals of big size. There was also a significant mass of Bony Fish (Clupeidae) (see Table 1). Molluscs were the basic food (MFI = 51.43), then Chordata (MFI = 23.30), Shellfishes (MFI = 11.25) and plants (MFI = 2.55) with Macrophyta very slightly represented (MFI = 0.23). Other animals' presence (Isopoda, Bryozoa, Decapoda, Anomura and Brachyura, Annelida, Nematoda, eggs) in seabream food was insignificant, i.e. less than 1. Finally, the food index of Zander (1982) showed that all the ingested preys were additional (MFI < 0.25).

In winter, Eumetazoa and Platelminta show very close MFI values (= 14.74 and 13.46), and nearly the same one in autumn (MFI = 4.16). Plants residues are almost inexistent in both seasons and molluscs are slightly represented. The number and the mean weight of ingested preys during both seasons are Nm = 1.91; Pm = 1.85 g in winter and Nm = 2.77; Pm = 4.03 g in autumn. Amphipoda, Isopoda, Macroura, Brachyura and Echinodermata are totally absent during both seasons. It should be noted that seabreams decrease their feeding activity by consuming less variety of preys in winter. Spearman's coefficient values are insignificant ($\rho = 1.09$; tobs = 0.78; $p < 0.05$).

In spring and summer, the molluscs consumption is more important (MFI = 44.21 in spring; 36.41 in summer); fishes consumption is higher in spring (MFI = 32.63), tending to decrease significantly in favour of crustaceans (MFI = 10.62) in summer. Echinodermata, Macrophyta and Thallophyta are practically absent in spring. The remaining preys are supplementary (MFI < 0.25). During both seasons, *S. aurata* seems to consume more prey masses with a mean number of N = 4.97 (Pi = 5.86 g in spring) and N = 6.86 (Pi = 3.67 g in summer). However, similarities in feeding habits during different seasons are confirmed by the insignificant coefficient value of Spearman correlation ($\rho = 1.35$; $p < 0.05$).

In both sexes, molluscs are first ranked (MFI = 53.25 for females and 44.75 for males), followed by fishes (MFI = 25.33 and 33.31, respectively); Shellfishes are significant in both sexes (MFI = 9.21 and 9.45) (Table 3). For the remaining preys, females seem to consume Eumetazoa (MFI = 6.59) and Platelminta (MFI = 5.60) more than males do (MFI = 1.93 and 1.52, respectively). The plant fraction is significant for males (MFI =3.37) and almost zero for females. Apparently, the number and the mean weight of preys ingested by females (N= 1.98; P = 5.98 g) are different from those observed in males (N = 6.23; P = 5.01 g), nevertheless, despite of numerical and weight value differences among preys, statistical analysis shows no significant differences thus suggesting feeding homogeneity between both sexes ($\rho = 1.53$; tobs = 0.45; $p < 0.05$).

Condition coefficient IC (fitness)

The monthly values of IC condition index of the whole population of *S. aurata*, show a low variation, lying generally between 0.61 and 1.33 (0.3 ± 0.86). The monthly evolution of condition index reflects homogeneity (Fig. 2).

Low values are observed in autumn (IC = 0.41 ± 0.02), but remain stable during the whole year with a mean value of IC = 0.14 ± 0.09. This coefficient doesn't seem to vary in time and statistically is insignificant for both sexes: (tobs = 0.36 ; P = 0.25; and tobs = 0.82 ; P = 0.428).

DISCUSSION

The *Sparus aurata* of the eastern coast of Algeria, is a carnivorous predator. Its significant diversification reflects a mean annual stomach Vacuity index equal to 35.21 %, during the whole year. This coefficient varies during the reproduction period as well from November to January in the eastern area of Algeria. It reaches a significant value in January; this possible short fasting period in winter is closely related to the species sexual cycle and to hydroclimatic conditions (low temperature).

The monthly variations of Vacuity index show a seasonal food pace of a strong feeding activity in spring and summer, due to gametogenesis preparation and reserve accumulation of adiposity in autumn. Food declines without interruption; this reserve accumulation is followed by a short fasting period (in January) after reproduction.

However, from December to January, during its full egg-laying season, the stomach Vacuity index reaches a value of 81.82%. It should be noted that a part of the population continues to feed and seems

not to be concerned by reproduction. The varied values of the Vacuity index during the seasons reflect prey frequency and availability in the environment. Similar results have been reported for other coastal Sparidae, i.e. *Diplodus annularis* (Derbal et al., 2007) and *D. cervinus cervinus* (Derbal & Kara, 2006). Considering its functional feeding level (Pauly & Christensen, 2000), *Sparus aurata* feeds mainly on flesh. In the eastern coast of Algeria, the presence of food including Cephalopoda and Gasteropoda, in addition to a significant number of Bivalvia (which can be crushed by means of its powerful molars), benthic shellfishes, fishes (Osteichthyes, Clupeidae) and others (Cestoda, Amphipoda, eggs), implies the erratic aspect of this species, having the ability to move vertically

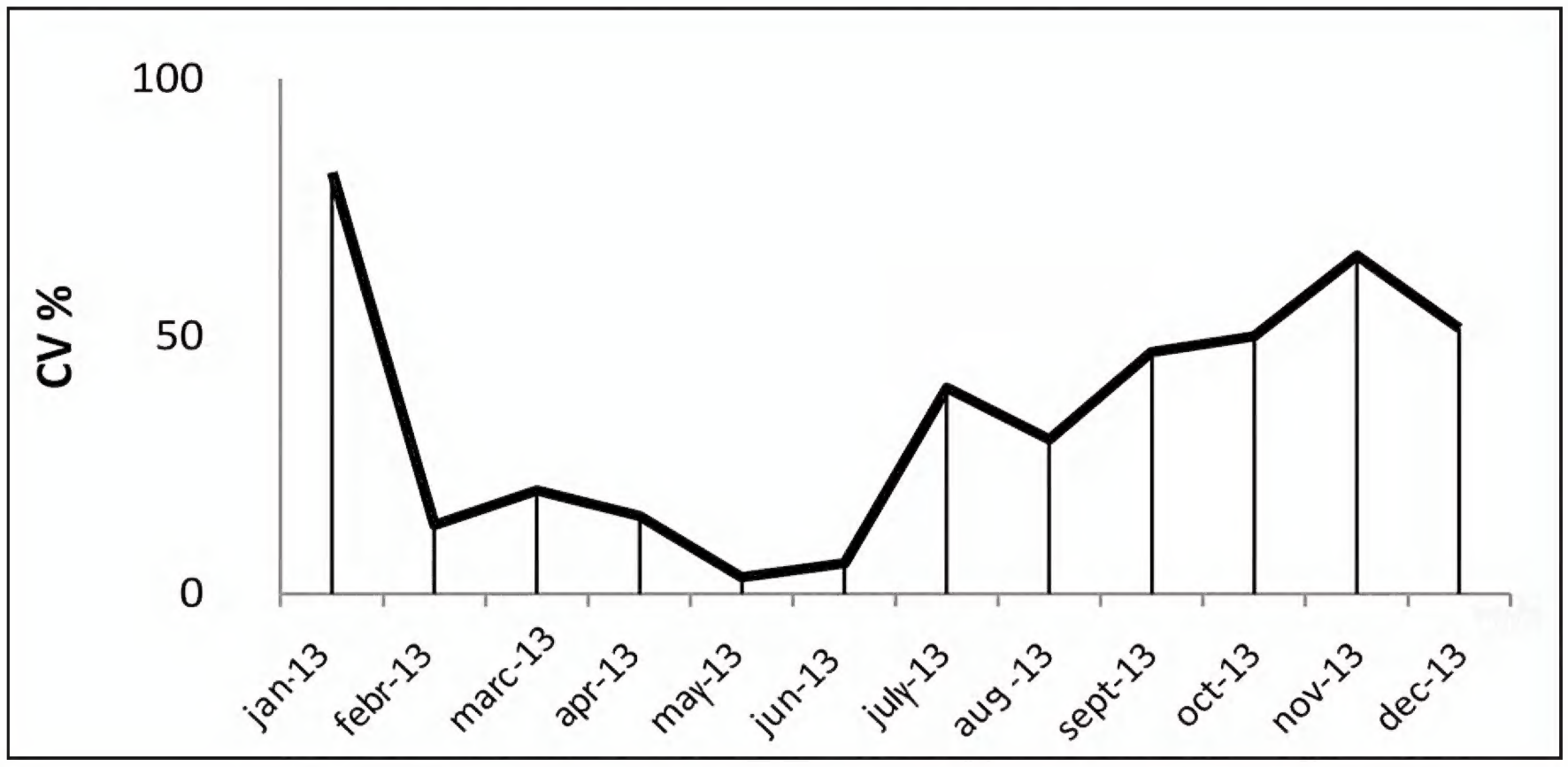

Figure 1. Monthly evolution of Vacuity index of *Spaurus aurata* of both Skikda and Annaba gulfs (Northeast of Algeria).

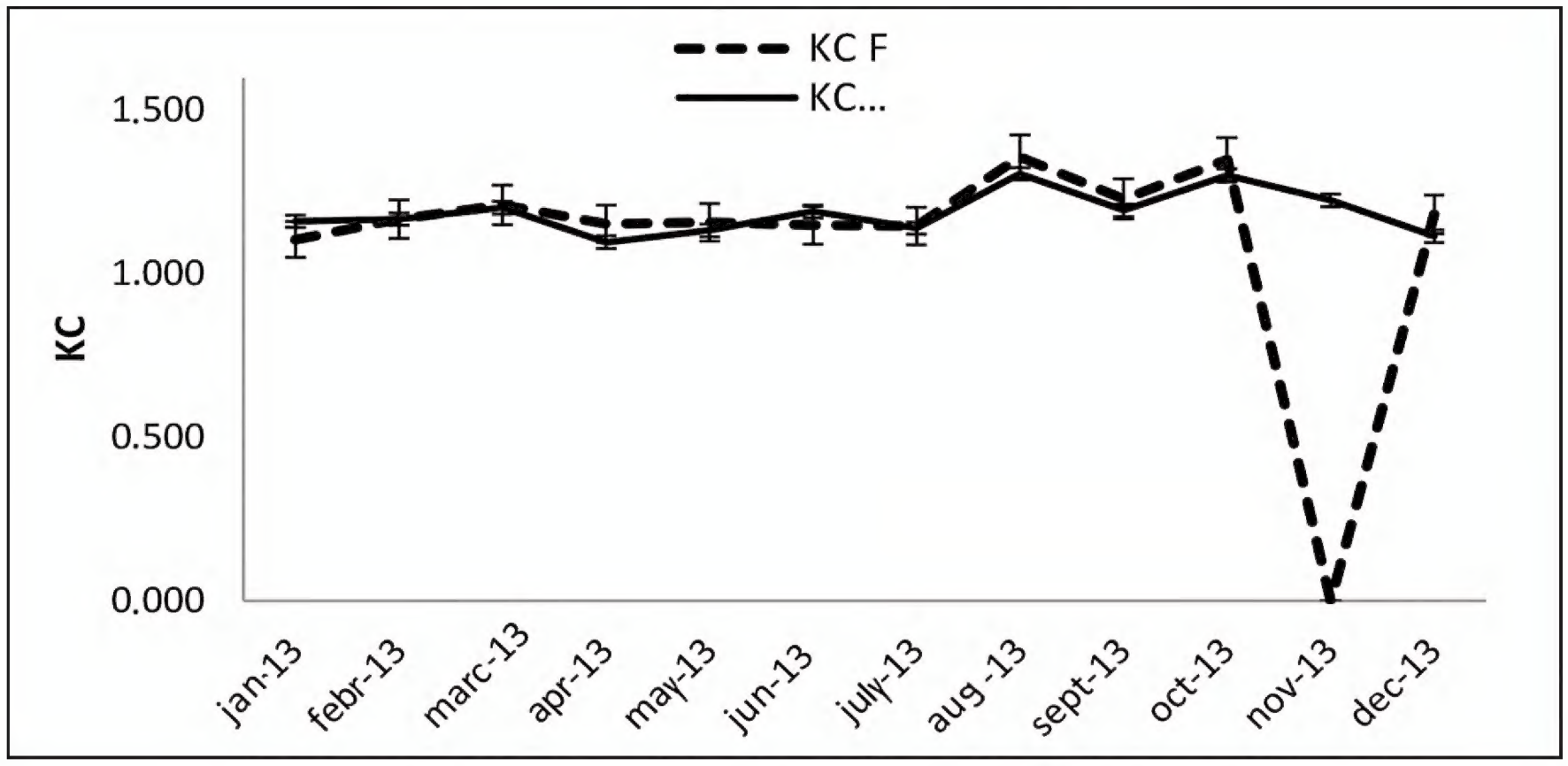

Figure 2. Monthly variation of the Algerian condition coefficient IC by both *Spaurus aurata* sexes in Eastern coast of Algeria.

(Harmelin, 1987), feeding basically on zooplanctonic preys, such as *Spicara* sp. (Harchouche, 2006), *Chromis chromis* (Dulčić, 2007), *Oblada melanura* (Pallaoro et al., 2003) and *Trachurus* sp. (Ben-salem, 1988; Šantić et al., 2003). Seabream food ethology approximates others Sparidae coastal ones, as *O . melanura* (Pallaoro et al., 2003).

Despite a diversification of 10 identified taxa, the feeding habits are basically made up of Gasteropoda, Bivalvia and Teleostei, in addition to Crustacea. This result, according to Arias (1980), is close to seabream's basic food in Cádiz estuary, based on molluscs, Bivalvia, Gasteropoda and shellfishes. Other different feeding habits are also described (Pita et al., 2002; Tancioni et al., 2003) and show that seabream is an opportunistic predator which

	Winter					Spring					Summer					Autumn				
Items	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)	Ni(%)	Pi (%)	Fo (%)	MFI	IRI (%)
CRUSTACEA	38.04	25.44	31.25	29.68	5.82	8.52	8.51	18.00	10.62	9.41	21.41	24.05	21.87	22.81	3.47	7.01	8.43	14.41	9.50	0.80
ECHINODERMATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.96	2.34	1.22	0.01	0.00	0.00	0.00	0.00	0.00
MOLLUSCA	1.08	1.79	1.56	1.54	0.01	70.33	35.01	41.33	44.21	133.64	43.60	43.63	17.18	36.41	5.24	0.27	0.65	0.90	0.62	0.00
CHORDATA	28.26	61.07	28.12	41.49	7.37	13.14	54.41	26.00	32.63	53.90	16.71	16.38	27.34	18.99	3.16	19.95	73.27	27.03	41.48	9.04
EUMETAZOA	26.08	8.01	28.12	14.74	2.81	7.28	1.51	12.66	3.89	3.42	5.74	1.01	11.71	2.97	0.27	2.43	4.42	5.41	4.16	0.13
ANNELIDA	2.17	0.13	3.12	0.60	0.02	2.48	0.25	5.33	0.99	0.44	2.08	0.42	5.46	1.27	0.04	0.00	0.00	0.00	0.00	0.00
BRYOZOA	1.08	0.04	1.56	0.24	0.00	0.53	0.02	1.33	0.16	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLATELMINTA	22.82	7.83	23.43	13.46	2.11	3.02	1.10	5.33	2.14	0.67	3.65	0.58	6.25	1.70	0.09	2.43	4.42	5.41	4.16	0.13
NEMATELMINTA	0.00	0.00	0.00	0.00	0.00	1.24	0.13	0.66	0.35	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MACROPHYTA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.43	1.56	0.67	0.00	0.00	0.00	0.00	0.00	0.00
TALLOPHYTA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.25	2.34	0.63	0.00	0.00	0.00	0.00	0.00	0.00
OTHERS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.56	0.04	0.00	0.00	0.00	0.00	0.00	0.00

Table 2. Seasonal food composition of *Sparus aurata* in Skikda and Annaba Gulfs (Northeast of Algeria), [Fo: frequency of prey's occurrence. Ni: Prey's numeric percentage (items). Pi: Prey's weight percentage (items). MFI: Main Food Index.]

	male				female			
Items	MFI 1/2	IRI(%)	Rang	IP %	MFI 1/2	IRI(%)	Rang	IP %
CRUSTACEA	9.456	0.935	3	4.081	9.219	0.739	3	3.069
ECHINODERMATA	0.000	0.000	10	0.000	0.000	0.000	10	0.000
MOLLUSCA	44.758	12.831	1	51.022	53.256	14.126	1	70.085
CHORDATA	33.310	6.232	2	43.765	25.558	3.949	2	24.983
EUMETAZOA	1.931	0.111	6	0.182	6.591	0.673	4	1.594
ANNELIDA	0.186	0.007	9	0.002	0.477	0.011	7	0.008
PLATELMINTA	1.522	0.051	7	0.108	0.047	0.000	10	0.000
NEMATELMINTA	0.000	0.000	10	0.000	5.605	0.418	5	1.200
VEGETALIA	3.373	0.151	4	0.577	0.238	0.002	10	0.001
MACROPHYTA	0.000	0.000	10	0.000	2.417	0.085	6	0.269
TALLOPHYTA	0.496	0.003	8	0.013	0.000	0.000	10	0.000
OTHERS	2.669	0.047	5	0.374	0.000	0.000	10	0.000

Table 3. Change of *Spaurus aurata* feeding habits by sex in the gulfs of Skikda and Annaba (Northeast of Algeria). IP %: the preponderance index.

adapts its feeding habits to prey availability in its environment. Seabream of Skikda and Annaba gulfs show similar food habits, although in different quantities.

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Contemporary spatial distribution pattern, breeding status and habitat suitability criteria for the African skimmer, *Rynchops flavirostris* Vieillot, 1816 (Aves Laridae) in the Zambezi Valley, Zimbabwe

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ABSTRACT

Reports indicate a decline in spatial distribution, reproduction and population size of the African Skimmer, *Rynchops flavirostris* Vieillot, 1816 (Aves Laridae) in the Zambezi Valley, Zimbabwe following construction of Lake Kariba. The objective of the present study was to assess contemporary distribution and breeding status of *R. flavirostris* in Lake Kariba and upstream and downstream of the lake in Zimbabwe. The study also developed habitat suitability criteria for Habitat Risk Index (Ri) and established the dominant substrates, soil moisture levels, soil temperature and food abundance for *R. flavirostris* in lentic and lotic environs of the Zambezi Valley, in order to establish the appropriate habitat conditions for the species. A survey method was used to determine *R. flavirostris* distribution and breeding status within the valley. Soil moisture level was measured by categorising levels into wet, damp, and dry soils and the category with the highest frequency was used to define habitat substrate moisture levels. Dominant substrate was visually estimated basing on proportion of soil particle sizes. Habitat risk was assessed on the basis of potential risk from anthropogenic and natural factors. Seine net fishing was conducted to estimate food abundance at sampling sites in Lake Kariba. Significant differences in sample means of measured habitat attributes between sites occupied by *R. flavirostris* and those unoccupied by the species were tested by two sample t tests with separate variance. One-way ANOVA was used to test for significant differences in habitat conditions among sampling sites. Three-way ANOVA was used to test for significant interactions of habitat conditions on *R. flavirostris* abundance in lentic and lotic environs. Preference ratios for habitat conditions were used to develop habitat suitability criteria. Results revealed that *R. flavirostris* was inhabiting and breeding in Lake Kariba and upstream and downstream of the lake. The species tolerance of habitat risk was observed to vary significantly ($p<0.05$, One-way ANOVA) among the three sections of the valley. Within the lake, *R. flavirostris* mostly preferred sandbars of moderate Habitat Risk Index ($0.4<R<0.7$). Contrary, *R. flavirostris* showed absolute preference to sandbars with low Habitat Risk Index ($R<0.4$) in habitats upstream and downstream of the lake. Significant differences ($p<0.05$; One-way ANOVA) in *R. flavirostris* abundance among sites of varying substrates were observed. Habitat Suitability Indices showed that *R. flavirostris* preferentially selected predominantly silty and sandy habitats in both lentic and lotic environs. Significant difference ($p<0.05$; One-way ANOVA) was also observed on *R. flavirostris* abundance among sites with different soil moisture content in the valley. *R. flavirostris* showed low preference for dry habitats in both lentic and lotic environs. No significant difference ($p>0.05$; One-way ANOVA) in temperature was observed on sandbars occupied by *R. flavirostris* within the lake and upstream and downstream of the lake. *R. flavirostris* preferentially selected sandbars with food abundances greater than 0.15 fish/m^2 within Lake Kariba. This study conclusively revealed that food availability, dominant substrate, soil moisture level and habitat risk emanating from both natural and anthropogenic factors at sandbars were important determinants of habitat suitability criteria for *R. flavirostris* in the Zambezi Valley.

KEY WORDS *Rynchops flavirostris*; spatial distribution; breeding status; habitat suitability.

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INTRODUCTION

River obstruction and hydrological alterations are commonly associated with habitat changes for lotic species (Bunn & Arthington, 2002). The damming of the Zambezi River during construction of Lake Kariba in the 1950s resulted in habitat alterations for riverine avian species. One species that was profoundly affected by the construction of the lake was the African Skimmer (*Rynchops flavirostris*), an endemic, intra-African migrant species that inhabited large emergent sandbars on the Zambezi River channel (Irwin, 1981; Coppinger et al., 1988).

Rynchops flavirostris is one of the Important Bird Area (IBA) trigger species that inhabits the Zambezi Valley whose spatial distribution, breeding status and population size were reportedly severely affected by the construction of Lake Kariba (Irwin, 1981; Donnelly & Donnelly, 1983; Coppinger et al., 1988; Tree, 1988; Wood & Tree, 1992; Hockey et al., 2005). The species then ultimately disappeared from the Lake Kariba environs after inundation of the river channel in 1968 (Irwin, 1981; Donnelly & Donnelly, 1983; Coppinger et al., 1988; Tree, 1988; Wood & Tree, 1992; Hockey et al., 2005). Elliott (1982) reported an estimate of *R. flavirostris* on this part of the Zambezi River at 100 birds in 1981. Fishpool & Evans (2001) subsequently gave an estimate of 136 birds as of 1986. *Rynchops flavirostris* breeding was reported to have completely ceased in the entire Mid-Zambezi Valley following the inundation. This led to severe decline of the species population within the valley (Wood & Tree, 1992). Most of the emergent sandbars which used to be special breeding grounds for *R. flavirostris* disappeared along the Zambezi River channel following construction of Lake Kariba (Irwin, 1981; Donnelly & Donnelly, 1983). Tree (1989) noted that Mozambique could be the only remaining breeding stronghold for *R. flavirostris* in the entire Zambezi Valley. The species is thus listed as near threatened (BirdLife International, 2012) owing to its small population and ongoing population decline.

Although the construction of the lake could have been the most significant factor in population decline of *R. flavirostris* in the Zambezi Valley, an amalgamation of habitat factors could have played a part. Studies have shown that a multiplicity of habitat factors simultaneously determine habitat suitability criteria for species (Brooks et al., 2005).

Avian species distribution is influenced by species functional requirements in relation to a range of biotic and abiotic factors within the ecosystem. Species habitat preferences are often a function of habitat stability. Sand bars are prone to natural and human disturbances. They are ideal sites for docking and for fishing. Derelict gillnets account for high mortalities of birds in aquatic systems (Zydelis et al., 2009). Sandbars are also foraging, drinking and resting sites for a number of herbivores and predators. Decline in reproduction success of *R. flavirostris* within the Zambezi valley and the subsequent species population crush could have been a result of human fisheries, predation of the species by crocodiles and Nile monitors as well as trembling of nests by large herbivores at sandbars (Coppinger et al., 1988). Erratic flooding of sand bars from opened flood gates is among possible habitat factors that determine habitat suitability for *R. flavirostris* in the Zambezi Valley (Coppinger et al., 1988). Climate change is another possible factor. So far, no comprehensive studies have been carried out to investigate effects of these various factors on habitats of *R. flavirostris* in the Zambezi Valley. An assessment of these factors is important, especially in lentic and lotic ecosystems where habitat conditions tend to flux as a result of natural events and anthropogenic activities.

The present study assessed contemporary spatial distribution pattern and breeding status of *R. flavirostris*, and developed habitat suitability criteria for the species within lentic and lotic habitats of the Zambezi Valley, Zimbabwe, about half a century after construction of Lake Kariba. Most recent studies on *R. flavirostris* are those by Coppinger et al. (1988) who studied distribution and breeding

biology of the species in the Upper and Middle Zambezi Valley, and reported on possible absence of the species within the Lake Kariba environs some two decades after construction of the lake. Habitat suitability criteria for Habitat Risk Index (R) that included dominant substrate, soil moisture level and soil temperature were developed for sandbars utilised by *R. flavirostris* for perching and feeding in Lake Kariba and in riverine habitats upstream and downstream of the lake. Habitat suitability function was also developed for food abundance within the lake.

Habitat selection is often in pursuit of food, breeding, as well as for provision of refuge from predation and other risks. Due to scarcity of nesting sites within the study area, the study was confined to the development of habitat suitability criteria for *R. flavirostris* for perching and feeding, but not for nesting. Effects of land use, river flow rate and climate on habitats of *R. flavirostris* within the Zambezi Valley were also not considered in the current study.

MATERIAL AND METHODS

Study area

The study was conducted in the mid-Zambezi Valley, in Zimbabwe and within Lake Kariba and its environs. The mid-Zambezi Valley is situated in northern Zimbabwe and part of Zambia and Mozambique. The Zambezi River is one of Africa's four largest rivers, and flows from north western Zambia to the Indian Ocean (Fishpool & Evans, 2001). The river drains from a catchment area that extends over eight countries, namely Zambia, Angola, Namibia, Botswana, Zimbabwe, Malawi, Tanzania and Mozambique. Its valley consists of unique terrestrial and aquatic habitats that support a diversity of flora and fauna. Timberlake (2000) estimated the biodiversity of the entire Zambezi basin to be between 6000 and 7000 plant species, about 195 mammalian species, 700 avian species, 165 fresh water fish species, 200 reptilian species and around 90 amphibian species.

Despite its importance as an area of high biodiversity, the Zambezi River and its catchment have experienced extensive anthropogenic pressure within the second half of the twentieth century. Construction of Lake Kariba in the 1950s, and the subsequent drastic shifting of land use in the mid-Zambezi Valley following the impoundment, altered the valley ecosystems. Impacts were particularly severe in submerged areas surrounding the lake. The present study covered three sections of the valley: (i) Lake Kariba, (ii) the Zambezi River channel upstream of Lake Kariba whose flow regime was presumed unaltered by the dam construction and (iii) the Zambezi River channel downstream of the lake whose flow regime was altered by the construction the lake.

Selection of sampling sites and sampling effort

A survey method, in conjunction with habitat recognition protocol, was employed in selecting sampling sites. Access of sampling sites was either by road or by boat, depending on accessibility and land owner permission. Basing on the assumption that all sandbars associated with lentic and lotic environs were potential habitats for *R. flavirostris*, identification of sampling sites was primarily based on presence of sandbars. For development of habitat suitability criteria, equal sampling effort was expended in the three sections of the Zambezi Valley, with a total of one hundred and eight surveys conducted on nine sandbars in each section over the period of July, August and October of 2014 and 2015.

Upstream of Lake Kariba, sampling was conducted along the river channel on the Zimbabwean side on nine sandbars situated between Kazungula Boarder Post and Victoria Falls, between geographical locations 17°48'14.82'S 025°16'6.99'E and 17°55'29.60'S 025° 51'1.85'E. Downstream of the lake, sampling was also carried out on nine sandbars along the Zambezi River channel on the Zimbabwean side. Downstream sites were situated between Vundu and Nyamatutsi, between geographical locations 15° 73.487'S 029° 34.965'E and 15° 70.327'S 029° 41.666'E. In Lake Kariba, sampling was conducted on nine sandbars along Kariba Town shoreline, stretching from the dam wall (16°32.199'S 28°45.459'E) to Charara River mouth (16°33.583'S 28°57.047'E). Sampling was also conducted on thirteen additional sites spanning across the entire Lake Kariba shoreline during two lake-wide surveys to establish presence or absence of *R. flavirostris* on other sections of the lake.

Sampling was conducted during the breeding season of *R. flavirostris*. The species is an inter-African migrant that breeds from July to October in Zimbabwe (Irwin, 1981).Surveys therefore coincide with species presence and breeding. Lake wide surveys to investigate presence of *R. flavirostris* on other sections of Lake Kariba were conducted from 28 August 2014 to 11 September 2014 and from 6 to 18 August 2015.

Distribution and breeding status of Rynchops flavirostris

In all three sections of the Zambezi Valley, Global Positioning System (GPS) readings were recorded at all sampling sites. Surveys involved the use of the point count protocol conducted from the water edge at the middle of each sandbar with limited distance of 100 m. A single point count (one contact) was performed at each sampling site per visit, and two visits were made per sampling site per sampling month. Observations were made with the aid of pairs of binoculars (Dialyt 8X30B). Point counts were conducted with the aim of establishing abundances of *R. flavirostris* at sampling sites. Surveys were conducted at sunrise and preceded for three hours. Counting lasted for 15 minutes per sampling site, and all *R. flavirostris* seen flying or resting at sampling site were recorded. Distances of resting birds from the water edge were estimated using a range finder and classified into four categories as follows: 0–5 m, 5–10 m, 10–15 m, and >15 m. Avian species occupying sandbars in company with *R. flavirostris* were recorded as associate species. Reporting rates (r_{yi}) were used to describe frequency of occurrence of associate species at each sampling site during the entire sampling period. Avian species at sandbars unoccupied by *R. flavirostris* were also recorded and their frequency of occurrence (r_{zi}) at the sites during the entire sampling period calculated. Species richness (S) was used to describe the number bird species at the sampling site. Following point counts, breeding status was investigated by walking and searching for nests and chicks on the entire sandbar.

Habitat characterisation

To establish habitat suitability criteria at sites utilised by *R. flavirostris* for perching and feeding, sandbars occupied by the species were characterised and compared with attributes from sandbars unoccupied by the species. Differences in sample means for all numerical data were tested by two sample t tests with separate variance. At each of the sampling sites, habitat characteristics were defined by soil moisture content, soil temperature, dominant substrate, and Habitat Risk Index (R_i). In Lake Kariba, habitat characterisation also included estimating food abundance for *R. flavirostris* at different sampling sites along Kariba Town shoreline.

Measuring soil temperature, soil moisture content and dominant substrate

Basing on observations that all *R. flavirostris* encountered in this study rested very close to water edges (within distance of 0–5 m from water mark) in both lentic and lotic ecosystems, species perching territory was set at 5 m from the water mark. Soil surface temperature, soil moisture level and dominant substrate were measured within the species perching territory at all sampling sites in order to characterise species habitat preferences for perch-ing and feeding. Measurements were taken lengthwise across sandbars by laying 100 m tape on either side of the centre of the sandbar at a distance of 2.5 m from the water mark. At each observation point, measurements were taken from a 0.5625 m^2 quadrant. Soil temperature (°C) and soil moisture content were measured at a depth of 1cm below the surface. Soil temperature was measured using a mercury thermometer. Mean surface temperature across the sandbar was used to describe substrate temperature. Soil moisture level was estimated by categorising moisture levels into three classes namely, wet, damp, and dry. The category with the highest frequency of occurrence was used to define substrate moisture levels at sampling sites. Dominant substrate was visually estimated based on proportion of soil particle size within the quadrant. Soil particle size category with the highest frequency of occurrence across the sandbar was used to describe dominant substrate at the sandbar. For sandbars with lengths less than 200 m, measurements were taken across the entire length of the sandbar.

Section of Zambezi Valley	Site	*Rynchops flavirostris* abundance			*Rynchops flavirostris* breeding status and flock size		
		July	August	September	July	August	September
Lake Kariba: Kariba Town Shoreline	**K1**	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K2	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K3	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K4	0;18*	19;13*	11;0*	0;0*	0;0*	0;0*
	K5	0;15*	16;17*	9;0*	0;0*	0;0*	0;0*
	K6	0;33*	34;23*	29;0*	0;0*	0; B3*	B2;N*
	K7	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K8	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K9	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
Lake Kariba: Lake-wide shoreline	**K10**	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K11	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K12	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K13	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K14	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K15	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K16	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K17	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K18	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K19	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K20	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	K21	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*

Table 1/1. *Rynchops flavirostris* abundances and breeding status at sampling sites in the lentic and lotic environs of the Zambezi Valley, Zimbabwe. Observations made in 2015 are denoted by * and B represents breeding observed on site e.g. B3*= breeding and 3 young ones observed in 2015.

Section of Zambezi Valley	Site	*Rynchops flavirostris* abundance			*Rynchops flavirostris* breeding status and flock size		
		July	August	September	July	August	September
Zambezi River: upstream habitats	**V1**	3;2*	5;4*	9;7*	0;0*	0;0*	0;0*
	V2	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	V3	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	V4	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	V5	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	V6	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	V7	13;11*	17;15*	28;18*	0;0*	0;0*	B5;0*
	V8	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	V9	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
Zambezi River: downstream habitats	**M1**	14;12*	15;13*	17;15*	0;0*	0;0*	0;0*
	M2	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	M3	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	M4	0;13*	16;12*	13;0*	0;0*	0;0*	0;0*
	M5	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	M6	17;8*	19;11*	26;17*	0;0*	0;0*	B3;0*
	M7	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	M8	0;0*	0;0*	0;0*	0;0*	0;0*	0;0*
	M9	12;14*	17;14*	12;18*	0;0*	0;0*	0;0*

Table 1/2. *Rynchops flavirostris* abundances and breeding status at sampling sites in the lentic and lotic environs of the Zambezi Valley, Zimbabwe. Observations made in 2015 are denoted by * and B represents breeding observed on site e.g. B3*= breeding and 3 young ones observed in 2015.

Common Name	**Scientific Name**	**Kariba Town Shoreline**								
		K1 r_{zi}	K2 r_{zi}	K3 r_{zi}	K4 r_{yi}	K5 r_{yi}	K6 r_{yi}	K7 r_{zi}	K8 r_{zi}	K9 r_{yi}
African Skimmer	*Rynchops flavirostris*	0	0	0	0.67	0.67	0.67	0	0	0.33
African Fish Eagle	*Haliaeetus vocifer*	0.17	0.33	0	0.33	0.17	0	0.33	0.67	0.33
African Jacana	*Actophilornis africanus*	0	0	0	0.17	0	0	0	0	0.33
African Pied Wagtail	*Motacilla aguimp*	0	0	0	0	0	0	0	0	0
African Spoonbill	*Platalea alba*	0	0	0	0	0	0	0	0	0
Black Smith Plover	*Vanellus armatus*	0.33	0.17	0.33	0.83	0.67	0.33	0.17	0.33	0.83
Black-headed Heron	*Ardea melanocephala*	0	0	0	0	0	0	0	0	0
Black-winged Stilt	*Himantopus himantopus*	0	0	0	0	0	0	0	0	0
Bohm's Spinetail	*Neafrapus boehmi*	0	0	0	0	0	0	0	0	0
Cattle Egret	*Bubulcus ibis*	0.33	0.67	0.33	1	1	1	0.67	0.83	1
Common Sand piper	*Actitis hypoleucos*	0	0	0	0.33	0	0.67	0	0	0.83
Darter	*Anhinga melanogaster*	0	0	0	0	0	0	0	0	0
Egyptian Goose	*Alopochen aegyptiacus*	0.5	0.17	0	1	1	1	0.17	0.17	1
Glossy Ibis	*Plegadis falcinellus*	0.17	0	0	1	1	1	0	0.17	1
Goliath Heron	*Ardea goliath*	0	0	0	0.17	0	0.33	0	0.33	0
Great White Egret	*Egretta alba*	0	0	0	0	0	0	0	0	0
Green-Backed Heron	*Butorides striatus*	0	0	0	0	0	0	0	0	0
Greenshank	*Tringa nebularia*	0	0	0	0	0	0	0	0	0
Grey Heron	*Ardea cinerea*	0.17	0	0	0.33	0	0.17	0	0.33	0.67
Grey-headed Gull	*Larus cirrocephalus*	0	0.17	0	1	1	1	0.33	0	1
Hadeda Ibis	*Bostrychia hagedash*	0	0	0	0	0	0	0	0	0
Hammerkop	*Scopus umbretta*	0.17	0	0	0.33	0	0	0.17	0.33	0
Knob-billed Duck	*Sarkidiornis melanotos*	0	0	0	0	0	0	0	0	0
Little Egret	*Egretta garzetta*	0	0	0	0	0	0	0	0	0
Longtoed Plover	*Vanellus crassirostris*	0	0	0	0	0	0	0	0	0
Marabou Stork	*Leptoptilos crumeniferus*	1	1	0.83	0.5	1	0.83	1	0.33	0.5
Open-billed Stork	*Anastomus lamelligerus*	0	0.33	0.5	0	0.17	0.33	0	0.67	0.17
Pied Kingfisher	*Ceryle rudis*	0	0	0	0.33	0	0.5	0	0	0.67
Reed Commorant	*Phalacrocorax africanus*	1	0	1	1	0.83	1	0.67	1	1
Rock Pratincole	*Glareola nuchalis*	0	0	0	0	0	0	0	0	0
Sacred Ibis	*Threskiornis aethiopicus*	0	0	0	1	1	1	0	0	1
Saddle-billed Stork	*Ephippiorhynchus senegalensis*	0	0.33	0	0.17	0.33	0	0.17	0	0.67
Spurwing Goose	*Plectropterus gambensis*	0	0	0	0	0	0	0	0	0
Squacco Heron	*Ardeola ralloides*	0	0	0	0	0	0	0	0	0
Water Dikkop	*Burhinus vermiculatus*	0	0	0	0	0	0	0	0	0
White Stork	*Ciconia ciconia*	0	0	0	0	0.33	0	0	0	0.17
White-crowned Plover	*Vanellus albiceps*	0	0	0	0	0	0	0	0	0
White-faced Duck	*Charadrius marginatus*	0.5	0	0.17	1	0.83	0.5	0.5	0.33	0
White-fronted Plover	*Charadrius marginatus*	0.5	0.33	0.17	1	1	1	0.3	0	1
Woolly-necked Stork	*Ciconia episcopus*	0	0	0	0	0	0	0	0	0
Yellow-billed Stork	*Mycteria ibis*	0.17	0	0.33	0.5	0.17	0.33	0.17	0	0.33
Cumulative number of species (S)		12	9	8	20	16	17	12	12	19

Table 2/1. *Rynchops flavirostris* associate species and their respective reporting rates ryi and rzi (defined in text) at sampling sites during the sampling period in the lentic and lotic environs of the Zambezi Valley, Zimbabwe.

Common Name	Scientific Name	Site V1 r_{yi}	V2 r_{zi}	V3 r_{zi}	V4 r_{zi}	V5 r_{zi}	V6 r_{zi}	V7 r_{yi}	V8 r_{zi}	V9 r_{zi}
African Skimmer	*Rynchops flavirostris*	1	0	0	0	0	0	1	0	0
African Fish Eagle	*Haliaeetus vocifer*	0.17	0.17	0.33	0	0	0.17	0.33	0	0
African Jacana	*Actophilornis africanus*	0.33	0	0.33	0	0.17	0	0.67	0.67	0.5
African Pied Wagtail	*Motacilla aguimp*	0	0.17	0	0	0.33	0	0	0	0.17
African Spoonbill	*Platalea alba*	0	0	0	0	0	0	0	0	0
Black Smith Plover	*Vanellus armatus*	0.67	0	0	0	0	0	0.5	0	0
Black-headed Heron	*Ardea melanocephala*	0	0	0	0	0	0	0	0	0
Black-winged Stilt	*Himantopus himantopus*	0.5	0	0	0	0	0	0.3	0	0
Bohm's Spinetail	*Neafrapus boehmi*	0	0	0	0	0	0	0	0	0
Cattle Egret	*Bubulcus ibis*	1	0.17	0.33	0.67	0.5	0.33	1	0.5	0.33
Common Sand piper	*Actitis hypoleucos*	0	0.17	0	0.33	0.33	0	0	0.17	0.33
Darter	*Anhinga melanogaster*	0.17	0	0.17	0	0	0	0	0	0
Egyptian Goose	*Alopochen aegyptiacus*	1	0.5	0.67	0.17	0.33	0.17	1	0.33	0.17
Glossy Ibis	*Plegadis falcinellus*	1	0.33	0.5	0.17	0	0.17	1	0.17	0.33
Goliath Heron	*Ardea goliath*	0	0	0	0	0	0	0	0	0
Great White Egret	*Egretta alba*	0	0	0	0	0	0	0	0	0
Green-Backed Heron	*Butorides striatus*	0	0.17	0	0	0.33	0	0	0.17	0
Greenshank	*Tringa nebularia*	0	0	0	0	0	0	0	0	0
Grey Heron	*Ardea cinerea*	0	0	0	0	0	0	0	0	0
Grey-headed Gull	*Larus cirrocephalus*	1	0	0	0	0	0	1	0	0
Hadeda Ibis	*Bostrychia hagedash*	0	0	0	0	0	0	0.17	0	0
Hammerkop	*Scopus umbretta*	0	0.33	0	0.17	0	0.33	0	0.17	0
Knob-billed Duck	*Sarkidiornis melanotos*	0	0.17	0.33	0.17	0	9	0	0	0
Little Egret	*Egretta garzetta*	0.17	0	0	0	0	0	0.33	0	0
Longtoed Plover	*Vanellus crassirostris*	0	0	0	0	0	0	0	0	0
Marabou Stork	*Leptoptilos crumeniferus*	0	0	0	0	0	0	0	0	0
Open-billed Stork	*Anastomus lamelligerus*	0.5	0.33	0.67	0.17	0	0	0.17	0	0.33
Pied Kingfisher	*Ceryle rudis*	0	0.67	0.17	0.5	0	0.5	0	0	0.17
Reed Commorant	*Phalacrocorax africanus*	0.17	0.5	0.33	0.17	0.5	0.83	0.17	0.33	0.5
Rock Pratincole	*Glareola nuchalis*	0	0.17	0	0	0.33	0	0	0.17	0
Sacred Ibis	*Threskiornis aethiopicus*	1	0	0	0	0	0	1	0	0
Saddle-billed Stork	*Ephippiorhynchus senegalensis*	0	0.17	0.33	0.17	0	0	0	0.33	0
Spurwing Goose	*Plectropterus gambensis*	0.33	0	0	0.17	0	0	0	0.17	0
Squacco Heron	*Ardeola ralloides*	0	0	0	0	0	0	0	0	0
Water Dikkop	*Burhinus vermiculatus*	0	0	0	0	0	0	0	0	0
White Stork	*Ciconia ciconia*	0	0	0	0	0	0	0	0	0
White-crowned Plover	*Vanellus albiceps*	0.5	0.33	0.67	0.33	0.17	0.5	0.5	0.33	0.67
White-faced Duck	*Charadrius marginatus*	0	0	0	0	0	0	0	0	0
White-fronted Plover	*Charadrius marginatus*	1	0	0	0	0	0	1	0	0
Woolly-necked Stork	*Ciconia episcopus*	0	0	0	0	0	0	0	0	0
Yellow-billed Stork	*Mycteria ibis*	0	0	0	0	0	0	0	0	0
Cumulative number of species (S)		17	15	12	12	9	9	16	12	10

Table 2/2. *Rynchops flavirostris* associate species and their respective reporting rates ryi and rzi (defined in text) at sampling sites during the sampling period in the lentic and lotic environs of the Zambezi Valley, Zimbabwe.

Common Name	**Scientific Name**	**Site**								
		M1	M2	M3	M4	M5	M6	M7	M8	M9
		r_{yi}	r_{zi}	r_{zi}	r_{yi}	r_{zi}	r_{yi}	r_{zi}	r_{zi}	r_{yi}
African Skimmer	*Rynchops flavirostris*	1	0	0	0.67	0	1	0	0	1
African Fish Eagle	*Haliaeetus vocifer*	0.5	0.67	0.33	0.67	0.17	0.33	0.5	0.67	0.67
African Jacana	*Actophilornis africanus*	0.5	0.67	0.33	0.17	0.67	0.33	0.17	0.5	0.5
African Pied Wagtail	*Motacilla aguimp*	0	0	0	0	0	0	0	0	0
African Spoonbill	*Platalea alba*	0.17	0.17	0.33	0.5	0.17	0.33	0.33	0	0.17
Black Smith Plover	*Vanellus armatus*	0.5	0.33	0.67	0.83	0.5	0.33	0.17	0.5	0.33
Black-headed Heron	*Ardea melanocephala*	0.33	0	0	0.17	0	0.17	0	0	0.33
Black-winged Stilt	*Himantopus himantopus*	0.5	0.33	0.67	0.83	0.5	0.33	0.17	0.5	0.33
Bohm's Spinetail	*Neafrapus boehmi*	0.17	0	0	0	0	0.17	0	0	0
Cattle Egret	*Bubulcus ibis*	1	0.33	0.83	1	0.67	1	0.83	0.5	1
Common Sand piper	*Actitis hypoleucos*	0.17	0	0.33	0	0	0.17	0.33	0	0.17
Darter	*Anhinga melanogaster*	0	0	0	0	0	0	0	0	0
Egyptian Goose	*Alopochen aegyptiacus*	1	0.83	0.33	1	0.33	1	0.17	0.33	1
Glossy Ibis	*Plegadis falcinellus*	1	0.83	0.17	1	0.33	1	0.33	0	1
Goliath Heron	*Ardea goliath*	0	0.17	0.33	0	0	0	0.17	0	0
Great White Egret	*Egretta alba*	0.5	0.67	0.33	0	0	0.17	0	0.33	0.17
Green-Backed Heron	*Butorides striatus*	0	0	0	0	0	0	0	0	0
Greenshank	*Tringa nebularia*	0.17	0.33	0	0	0	0.17	0	0.33	0
Grey Heron	*Ardea cinerea*	0.17	0	0	0	0	0.33	0	0	0
Grey-headed Gull	*Larus cirrocephalus*	1	0.33	0.17	1	0.17	1	0.33	0.17	1
Hadeda Ibis	*Bostrychia hagedash*	0.17	0	0.33	0	0	0.17	0	0	0.33
Hammerkop	*Scopus umbretta*	0	0.17	0.33	0	0	0	0.33	0.17	0
Knob-billed Duck	*Sarkidiornis melanotos*	0	0	0	0	0	0	0	0	0
Little Egret	*Egretta garzetta*	0	0	0	0.33	0	0.17	0	0	0
Longtoed Plover	*Vanellus crassirostris*	0.33	0	0	0.17	0	0	0	0	0.33
Marabou Stork	*Leptoptilos crumeniferus*	0	0	0	0	0	0	0	0	0
Open-billed Stork	*Anastomus lamelligerus*	0.33	0	0	0.17	0	0.33	0	0	0
Pied Kingfisher	*Ceryle rudis*	0	0	0	0	0	0	0	0	0
Reed Commorant	*Phalacrocorax africanus*	0.5	0.67	0.33	0.67	0.83	0.67	0.5	0.5	0.67
Rock Pratincole	*Glareola nuchalis*	0	0	0	0	0	0	0	0	0
Sacred Ibis	*Threskiornis aethiopicus*	1	0	0	1	0	0.5	0	0	0.67
Saddle-billed Stork	*Ephippiorhynchus senegalensis*	0.33	0	0	0.17	0	0	0	0	0.17
Spurwing Goose	*Plectropterus gambensis*	0	0	0	0	0.33	0	0.17	0	0
Squacco Heron	*Ardeola ralloides*	0.17	0	0	0.33	0	0.67	0	0	0.33
Water Dikkop	*Burhinus vermiculatus*	0	0.17	0.33	0.33	0.17	0.17	0	0	0.33
White Stork	*Ciconia ciconia*	0	0	0	0	0	0	0	0	0
White-crowned Plover	*Vanellus albiceps*	0.33	0.17	0	0.17	0.33	0	0.17	0.33	0.5
White-faced Duck	*Charadrius marginatus*	0.5	0	0	0.33	0	0.33	0	0	0.33
White-fronted Plover	*Charadrius marginatus*	1	0	0	1	0	1	0	0	1
Woolly-necked Stork	*Ciconia episcopus*	0.17	0	0	0.33	0	0.33	0	0	0.17
Yellow-billed Stork	*Mycteria ibis*	0.5	0.33	0.17	0.5	0.17	0.33	0.17	0.33	0.5
Cumulative number of species (S)		28	17	17	24	14	27	16	13	25

Table 2/3. *Rynchops flavirostris* associate species and their respective reporting rates ryi and rzi (defined in text) at sampling sites during the sampling period in the lentic and lotic environs of the Zambezi Valley, Zimbabwe.

Site	K4	K5	K6	K8	V1	V7	M1	M4	M6	M9
First count July 2014	14	12	13	15	9	10	21	19	20	19
Second count July 2014	14	13	12	13	9	9	18	18	17	17
First count July 2015	13	10	10	8	6	6	16	14	16	15
Second count July 2015	11	11	10	11	7	7	17	16	13	11
Mean ± SD	13±1.41	11.5±1.29	11.3±1.5	11.8±2.99	7.8±1.5	8±1.83	18±2.16	16.8±2.22	16.5±2.89	15.5±3.42
First count August 2014	16	13	15	12	9	10	22	20	19	20
Second count August 2014	15	14	13	16	8	9	23	18	17	19
First count August 2015	12	10	12	10	8	8	21	16	13	15
Second count August 2015	10	9	11	11	7	8	20	17	15	13
Mean ± SD	13.3±2.75	11.5±2.38	12.8±1.7	12.3±2.63	8±0.82	8.8±0.96	21.5±1.29	18±2.16	16±2.58	16.8±3.3
First count October 2014	20	16	17	19	12	16	28	24	27	25
Second count October 2014	18	15	16	19	9	9	27	22	23	21
First count October 2015	18	13	16	17	7	11	25	20	21	20
Second count October 2015	17	13	15	18	10	8	23	21	20	20
Mean ± SD	18.3±1.25	14.3±1.5	16±0.8	18.3±0.96	9.5±2.08	6±8.57	25.8±2.22	21.8±1.71	22.8±3.1	21.5±2.38

Table 3. Avian associate species richness (S) , mean ± SD at sandbars occupied by *Rynchops flavirostris* in Lake Kariba (K4, K5, K6 and K9), and along the Zambezi River upstream of Lake Kariba (VI and V7) and downstream of Lake Kariba (M1, M4, M6,and M9).

Estimating Potential Habitat Risk

Potential habitat risk for *R. flavirostris* was assessed from sandbars on the basis of potential risk from anthropogenic and natural factors. A 100 m lengthwise protocol, with standard width of 15 m from water mark on either side of the middle of the sandbar, was used to quantify risk from boat traffic, human traffic, as well as presence and activity of crocodiles, Nile monitors, herbivores and derelict gillnets at sampling sites. The protocol assumed an extended zone of risk influence of 10 m outside the species perching territory. Habitat Risk Indices (R_i) at sampling sites were derived from Habitat Risk Ratios (H_{ri}) defined by Anthropogenic Risk Ratio (H_A) and Natural Risk Ratio (H_N). H_A and H_N for each sampling site were derived by summing the proportional contributions of individual Habitat Risk Ratios for each risk component as follows:

$$H_A = H_{r1} + H_{r2} + H_{r3} + H_{r4};\ \text{and}$$
$$H_N = H_{r5} + H_{r6} + H_{r7} + H_{r8} + H_{r9} + H_{r10} + H_{r11} + Hr_{r12}$$

Where H_{r1} = likelihood of presence of people at sampling site during the entire sampling period; H_{r2} = likelihood of presence of boats at sampling site during the entire sampling period; H_{r3} = likelihood of presence of derelict fishing nets at sampling site during the entire sampling period; H_{r4} = likelihood of encountering entangled birds by derelict fishing

nets at sampling site during the entire sampling period; H_{r5} = likelihood of encountering crocodiles at sampling site during the entire sampling period; H_{r6} = likelihood of encountering Nile monitors at sampling site during the entire sampling period; H_{r7} = likelihood of encountering active predation of *R. flavirostris* by crocodiles at sampling site during the entire sampling period; H_{r8} = likelihood of encountering active predation of *R. flavirostris* by Nile monitors at sampling site during the entire sampling period; H_{r9} = likelihood of encountering elephants at sampling site during the entire sampling period; H_{r10} = likelihood of encountering hippopotami at sampling site during the entire sampling period; H_{r11} = likelihood of encountering buffalos at sampling site during the entire sampling period; and H_{r12} = likelihood of observing trembled nests by herbivores at sampling site during the entire sampling period.

Habitat Risk Index (R_i) for each sampling site was then defined by the joint effect of habitat risk from anthropogenic factors and natural factors, and was arrived at by multiplying H_A and H_N for each sampling site, followed by normalising the values by dividing each by the highest to get R_i ranging between 0 and 1 as follows:

$$R_i = (H_{Ai})(H_{Ni})/f$$

Where R_i= Habitat Risk Index for sampling site i; H_{Ai} = Anthropogenic Risk Ratio at sampling site i; H_{Ni} = Natural Risk Ratio at sampling site *i*; and *f* = highest product of H_{Ai} and H_{Ni} among the sampling sites.

Estimating Food Abundance

Estimation of food abundance for *R. flavirostris* was conducted only in Lake Kariba along Kariba Town shoreline. Due to risks associated with seine net fishing in large rivers no estimates on food abundances for *R. flavirostris* along the Zambezi River channel both upstream and downstream of the lake were conducted. Presence of hippopotami and crocodiles compromised safety along the Zambezi River. Estimation of Food Abundance (F) for *R. flavirostris* along Kariba Town Shoreline was carried out in August of 2014 and in 2015. Seine net fishing was conducted using the encircling manoeuvre to estimate food abundance at sites occupied and those unoccupied by *R. flavirostris* along the shoreline. Three catches were conducted at each sampling site. The first catch was conducted at the midpoint of the sandbar, and the other two some 100 m away from the first position, on either side of the midpoint along the shoreline. Fish caught in the three catches were combined to form a composite sample, identified to species level, and their lengths measured to the nearest cm using a tape measure. For each catch, radius of the circle was measured in metres using GPS, and the surface area (m^2) for the catch was calculated using the formula of a circle (πr^2).

R. flavirostris feeds on non-cichlids 6 cm long or less (Coppinger et al., 1988). Mean catch of non-cichlids 6 cm long or less m^{-2} was used to describe food abundance for *R. flavirostris* at each sampling site.

***Developing habitat suitability criteria for* Rynchops flavirostris**

Development of species habitat suitability criteria has been done in numerous studies but there has been no clear consensus on a single standard method (Jowett, 2002). In this study, monthly variable data for dominant substrate, soil moisture level, soil temperature, Habitat Risk Index (R_i) and food abundance were categorised and used to derive habitat suitability criteria for *R. flavirostris* within the three sections of the Zambezi Valley. Habitat suitability functions were derived from measures of strength of selection for a particular habitat category as defined by Heath et al. (2015). Preference Ratios (Z_a) for individual habitat categories were calculated and used to develop habitat suitability criteria for *R. flavirostris* in the three sections of the Zambezi Valley. Preference ratios were computed by dividing mean abundance of *R. flavirostris* encountered in a given habitat category by mean abundance of the species in all habitat categories in relation to sampling effort within the study area. Z_a measured species preference levels of particular habitat condition in relation to sampling effort as follows:

$$Z_a = (\bar{a}/\bar{A})/(S_a/\sum S_{aj})$$

Where Z_a = Preference ratio for habitat condition *a*; $\bar{a}$= average abundance of *R. flavirostris*

within habitat category *a*; and $\bar{A}$ = average abundance of the species in all habitat categories; S_a = number of samples in category a; $\sum S_{aj}$ = total number of samples in all categories.

Habitat Preference ratios were then normalised by dividing them with the largest Z_a value to get Habitat Suitability Indices (Y_a) ranging between 0 and 1. Optimum range of a habitat condition was therefore assigned a weighting factor of 1, and the least suitable ranges assumed values near zero. To express habitat suitability functions, function fitting models were performed on habitat variables and correlations were considered significant at the 0.05 level.

RESULTS

Distribution and breeding status of Rynchops flavirostris

Rynchops flavirostris was recorded and its breeding sites observed in Lake Kariba and upstream and downstream of the lake (Fig. 1). Although no nesting behaviour and/or nesting scraps were observed with incubating eggs during the entire sampling period, flocks of *R. flavirostris* with their young were observed in the upstream and downstream of the lake. This suggested that the species was breeding in the three sections of the Zambezi valley. In Lake Kariba, a single nest with two unfledged chicks was recorded in August 2015, indicating resumption of breeding by *R. flavirostris* in the Kariba area. However, no nesting grounds were observed within the lentic and lotic habitats of the valley throughout the sampling period.

Rynchops flavirostris was observed on four of the nine sandbars sampled along Kariba Town shoreline (Fig. 1), where the species occupied sandbars with predominantly silty or sandy substrate. Within the lake environs the species occupied sandbars with high avian species richness (Table 2), and moderate to high levels of risk (Figs. 15–17). Flock sizes ranged between 9 and 34 within the Lake Kariba environs (Table 1), with highest flock sizes recorded at sites with food availability greater than 0.15 fish/m^2 (Figs. 24, 25).

In October 2014, two fledged juveniles were observed standing in shallow water with adults on the lake shoreline at Site K6. Further observations of juveniles were made at site K6 in August 2014, where three fledged juveniles were also observed resting with adult birds within a distance of less than 5 m from the water mark. In August 2015, two unfledged chicks were observed at Site K9 in damp sand some 9.6 m away from the water edge.

In upstream habitat, within the lotic environs of the Zambezi Valley, *R. flavirostris* was observed on two of the nine sandbars sampled (Fig. 1; Table 1), where it also occupied sandbars with predominantly silty or predominantly sandy substrate. In the upstream habitat *R. flavirostris* also occupied sandbars with high avian species richness (Table 2). However, contrary to the lake environs, the species preferred sandbars of low risk levels within the lotic habitat, upstream of Lake Kariba (Figs. 15–17).

Flock size ranged between 2 and 28 within the upstream habitat (Table 1). Five fledged juveniles were observed upstream in October 2014 on sampling site V7. The juveniles were resting with adult birds on the silty sandbar along the edges of the river within a distance of less than 5 m from the water.

In downstream environs *R. flavirostris* was observed on four of the nine sandbars sampled with flock size ranging between 8 and 26. The species also occupied sandbars with predominantly silty or predominantly sandy substrate with high associate avian species richness (Table 2). The species also showed selective preference of low risk levels within the lotic environs of the Zambezi River downstream of Lake Kariba (Figs. 15–17).

Breeding was observed only at one site (M6) out of the nine sites sampled (Table 1) downstream of Lake Kariba. Three fledged juveniles were observed at Site M6 resting with adult birds within a distance of less than 5 m from the water mark in October 2015.

Rynchops flavirostris *avian species association*

Common avian associate species of *R. flavirostris* in both the lentic and lotic environs of the Zambezi Valley were Cattle Egret *Bubulcus ibis* Linnaeus, 1758, Egyptian Goose *Alopochen aegyptiacus* (Linnaeus, 1758), Glossy Ibis *Plegadis falcinellus* (Linnaeus, 1758), Grey-headed Gull *Larus cirrocephalus* Vieillot 1818, Sacred Ibis *Threskiornis aethiopicus* Latham, 1790 and White-fronted Plover *Charadrius marginatus* Vieillot 1818. These species were al-

Habitat Variable	Section	Month	Correlation Coefficient & function
Boat traffic	Kariba	July	*0.015 (polynomial)
Boat traffic	Kariba	August	*0.068 (polynomial)
Boat traffic	Kariba	October	*0.371 (polynomial)
Boat traffic	upstream	July	*0.126 (polynomial)
Boat traffic	upstream	August	not derived
Boat traffic	upstream	October	*0.029 (polynomial)
Boat traffic	downstream	July	*0.047 (polynomial)
Boat traffic	downstream	August	not derived
Boat traffic	downstream	October	not derived
Human traffic	Kariba	July	*0.148 (polynomial)
Human traffic	Kariba	August	*0.195 (polynomial)
Human traffic	Kariba	October	*0.074 (polynomial)
Human traffic	upstream	July	*0.037 (polynomial)
Human traffic	upstream	August	*0.126 (polynomial)
Human traffic	upstream	October	*0.059 (polynomial)
Human traffic	downstream	July	*0.036 (polynomial)
Human traffic	downstream	August	*0.037 (polynomial)
Human traffic	downstream	October	*0.035 (polynomial)
Derelict gillnets	Kariba	July	*0.160 (polynomial)
Derelict gillnets	Kariba	August	*0.2519 (polynomial)
Derelict gillnets	Kariba	October	*0.104 (polynomial)
Derelict gillnets	upstream	July	not derived
Derelict gillnets	upstream	August	not derived
Derelict gillnets	upstream	October	not derived
Derelict gillnets	downstream	July	not derived
Derelict gillnets	downstream	August	not derived
Derelict gillnets	downstream	October	not derived
Elephant density	Kariba	July	*0.741 (polynomial)
Elephant density	Kariba	August	*0.246 (polynomial)
Elephant density	Kariba	October	*0.867 (polynomial)
Elephant density	upstream	July	*0.663 (polynomial)
Elephant density	upstream	August	*0.879 (polynomial)
Elephant density	upstream	October	*0.947 (polynomial)
Elephant density	downstream	July	0.116 (polynomial)
Elephant density	downstream	August	0.026 (polynomial)
Elephant density	downstream	October	*0.858 (polynomial)
Crocodile density	Kariba	July	0.046 (polynomial)
Crocodile density	Kariba	August	0.093 (polynomial)
Crocodile density	ariba	October	*0.132(polynomial)
Crocodile density	upstream	July	0.024 (polynomial)
Crocodile density	upstream	August	*0.124 (polynomial)
Crocodile density	upstream	October	0.05 (polynomial)
Crocodile density	downstream	July	0.024 (polynomial)
Crocodile density	downstream	August	0.016 (polynomial)
Crocodile density	downstream	October	0.032 (polynomial)
Hippopotamus density	Kariba	July	0.022 (linear)
Hippopotamus density	Kariba	August	0.025 (linear)
Hippopotamus density	Kariba	October	0.016 (linear)
Hippopotamus density	upstream	July	0.022 (linear)
Hippopotamus density	upstream	August	0.008 (linear)
Hippopotamus density	upstream	October	0.04 (linear)
Hippopotamus density	downstream	July	0.04 (linear)
Hippopotamus density	downstream	August	0.171 (linear)
Hippopotamus density	downstream	October	0.009 (linear)

Table 4. Function fitting and correlation coefficients (r^2) of *Rynchops flavirostris* abundance and habitat variables at sampling sites in the lentic and lotic environs of the Zambezi Valley, Zimbabwe. *$p<0.05$. Correlation is significant at the 0.05 level. r^2 for habitat variable data with mean=0 were not derived.

Temperature (°C)	20-22	22-24	24-26	26-28	28-30	30-32	32-34	>34
Kariba July	1	0.2	0	0	0	0	0	0
Kariba Aug	0	0	0	0.2	1	0	0	0
Kariba Oct	0	0	0	0	0	1	0.5	0
Upstream Jul	1	0.5	0	0	0	0	0	0
Upstream Aug	0	0	0	0.3	1	0	0	0
Upstream Oct	0	0	0	0	0	1	0.9	0
Downstream Jul	0.3	0.1	1	0	0	0	0	0
Downstream Aug	0	0	0	0.2	1	0	0	0
Downstream Oct	0	0	0	0	0	1	0.2	0

Table 5. Substrate temperature suitability index for *Rynchops flavirostris* in the lotic and lentic environs of the Zambezi Valley, Zimbabwe.

ways in association with *R. flavirostris* during the sampling period and scored reporting rate $r_{yi} = 1$ in all the three sections of the Zambezi Valley (Table 2).

Two sample t test indicated that there were significant differences ($p<0.05$) in avian associate species richness and species reporting rates between sites occupied by *R. flavirostris* and those unoccupied by *R. flavirostris* in all the three sections of the Zambezi Valley sampled in this study. Avian associate species richness and reporting rates were significantly higher at sandbars occupied by *R. flavirostris* than at sandbars unoccupied by *R. flavirostris* in all the three sections of the Zambezi Valley.

Number of avian associate species at sandbars occupied by *R. flavirostris* varied significantly ($p<0.05$; One-way ANOVA) among the three sections of the Zambezi Valley. Tukey's pair wise comparisons showed significant difference ($p<0.05$) in associate avian species richness between the lentic and lotic habitats. Lake Kariba had significantly higher avian associate species richness ($p<0.05$) than the upstream habitat. However, downstream habitat had significantly higher associate avian species richness ($p<0.05$) than the lake environs. During all sampling months, number of avian associate species (S) was highest downstream, followed by Lake Kariba. The least S was observed in upstream habitat (Figs. 2–4, Table 3).

Rynchops flavirostris *Habitat Characteristics and Habitat Suitability Criteria*

The principal component analysis (PCA) results revealed that Principal Component 1 explained 43% of the observed variation on sampling sites, while Principal Component 2 explained 28.6% and Principal Component 3 explained 9% of the observed variation among the sampling sites. Principal component biplot showed that *R. flavirostris* abundance and habitat risk factors accounted for most of the variance among the sampling sites (Fig. 5).

Habitat Risk

Weak, but significant, correlations were observed between *R. flavirostris* abundance and most of the habitat risk variables in all the three sampling months (Table 4). Except for elephant density, negative correlations were observed between *R. flavirostris* abundance and each of the individual habitat risk factors (human traffic, boat traffic, derelict gillnets, hippopotamus density and crocodile density) in all the three sections of the Zambezi Valley. Positive correlation was observed between elephant density and *R. flavirostris* abundance in all

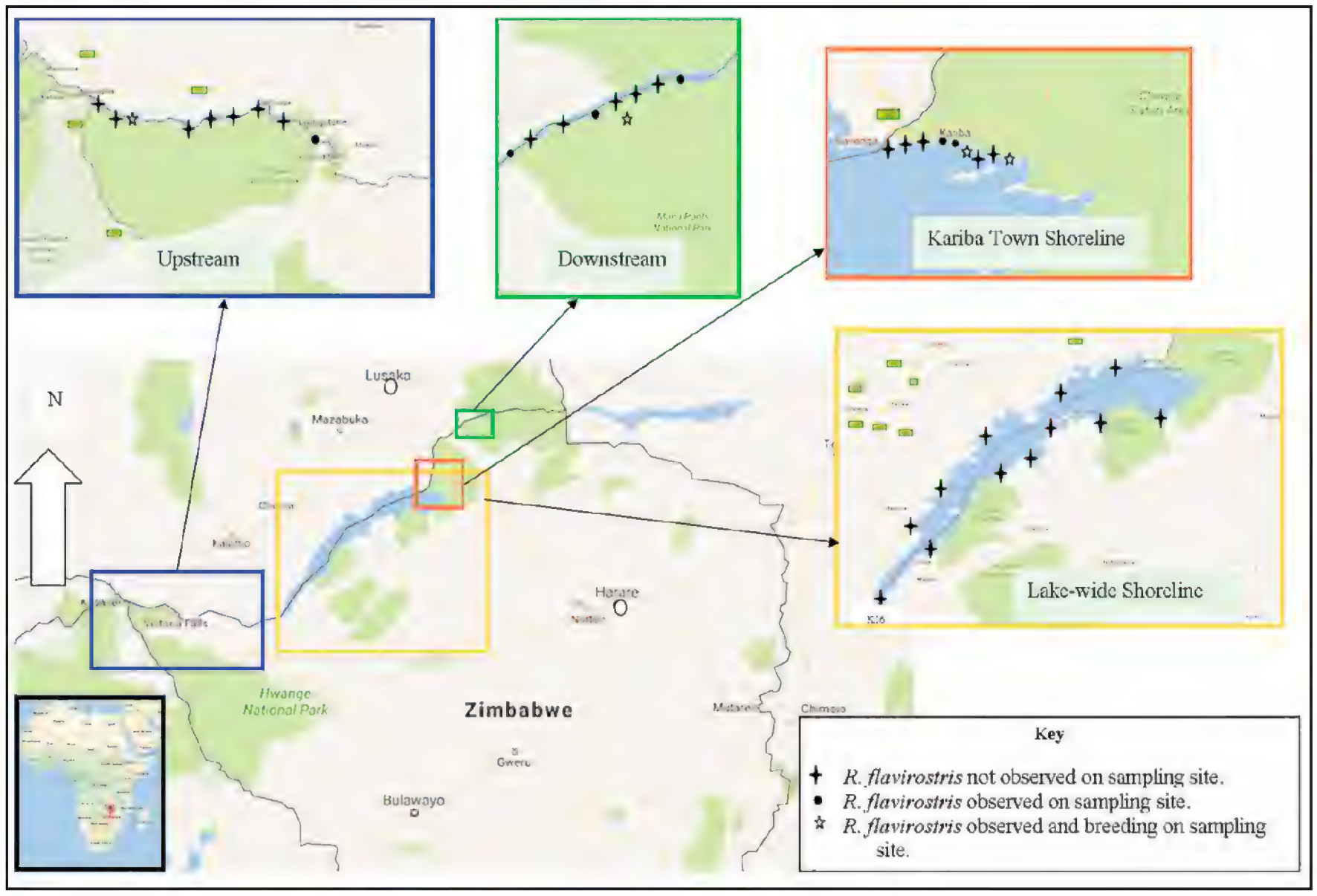


Figure 1. *Rynchops flavirostris* distributional pattern and breeding status at sampling sites in the lentic and lotic environs of the Zambezi Valley, Zimbabwe.

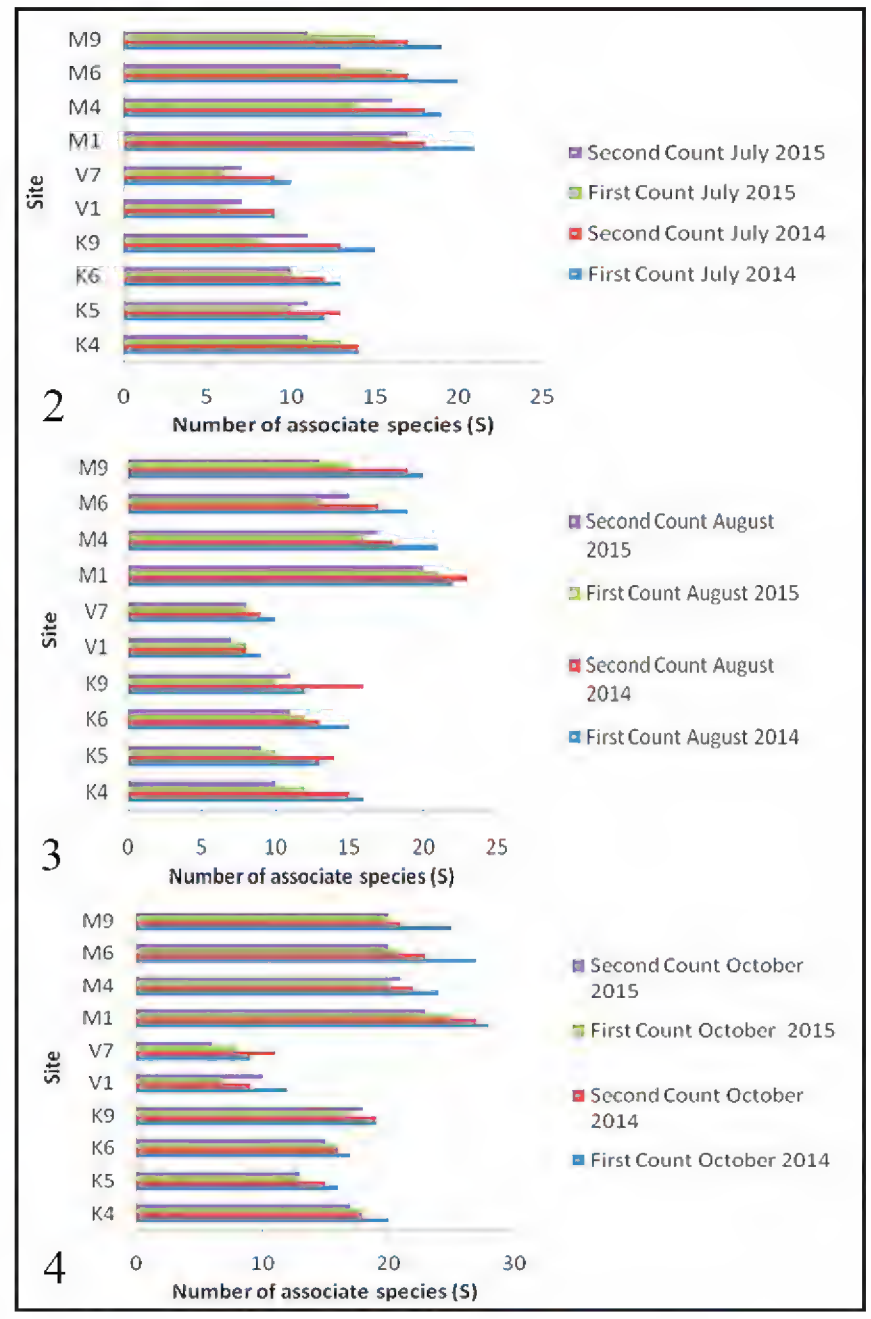
three sampling months in Lake Kariba, as well as in upstream and downstream habitats in October (Figs. 6–14). However, elephant density negatively correlated with *R. flavirostris* abundance in lotic habitats of the Zambezi Valley in July and August (Figs. 6–14).

Rynchops flavirostris tolerance to risk levels varied significantly ($p<0.05$, One-way ANOVA) among the three sections of the Zambezi Valley. In Lake Kariba, the species showed highest preference to sandbars of moderate risk index ($0.4< R <0.7$) and no preference to sandbars with low habitat risk index ($R <0.4$) (Figs. 15–17). Preference to sandbars of high habitat risk index ($R>0.7$) was low in Lake Kariba (Figs. 15-17). On the contrary, *R. flavirostris* showed preferential occupation of sandbars with low risk index ($R <0.4$) in habitats upstream and downstream of the lake on the Zambezi River (Figs. 15–17). The species showed no preference of sandbars of medium or high risk indices in upstream and downstream habitats along the lotic environs of the Zambezi River (Figs. 15–17).

Anthropogenic factors accounted for higher habitat risk at sampling sites in Lake Kariba than upstream and downstream of the lake. In Lake Kariba, risk contributed by anthropogenic factors (human traffic, boat traffic, presence of derelict gillnets, derelict gillnet activity) at sampling sites was significantly higher ($p< 0.05$; two sample t test) than from natural factors (risk from crocodiles, elephants and hippopotami). On the contrary, risk from anthropogenic factors was significantly lower ($p<0.05$; two sample t test) than risk from natural factors within the lotic habitats of the Zambezi River both upstream and downstream of Lake Kariba. Among the natural risk factors, presence of elephants contributed most to habitat risk followed by presence of hippopotami at sampling sites in both lentic and lotic environs. Presence and action of crocodiles scored the least risk indices in all the three sections of the valley. Nile monitors, buffaloes, carnivory incidences, and nest trembling by herbivores were not encountered at any of the sampling sites within all the three sections.

Natural habitat risk factors (presence of elephants, hippopotami, crocodiles) were observed in both the lentic and lotic environs. One-way ANOVA showed that across the three months sampled, elephant density varied significantly ($p<0.05$) among the three sections of the valley. Tests for effects of interactions revealed that there was no statistically significant three way interaction between section of the Zambezi Valley, sampling month and elephant density on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). There was also no statistically significant interaction between elephant density and sampling month, as well as section of the Zambezi Valley and elephant density ($p>0.05$; Three-way ANOVA) on *R. flavirostris* abundance. Tukey's pair wise comparisons showed significant difference ($p<0.05$) in elephant density between the lentic environs of Lake Kariba and lotic environs of the Zambezi River. However, significant difference was not observed ($p>0.05$) in elephant density between upstream and downstream environs of the Zambezi Valley. Two sample t test also showed no significant differences ($p>0.05$) in elephant density between sites occupied by *R. flavirostris* and those unoccupied by the species in all the three sections of the Zambezi Valley throughout all the sampling months.

One-way ANOVA showed that across the three months sampled, hippopotamus density varied significantly ($p<0.05$) among the three sections of the valley. Tests for effects of interactions revealed that



Figures 2–4. Monthly variation of number of avian associate species (S) at sandbars occupied by *Rynchops flavirostris* in Lake Kariba (K4, K5, K6 and K9), in the Zambezi River upstream of Lake Kariba (VI and V7) and in the Zambezi River downstream of Lake Kariba (M1, M4, M6,and M9) in Fig. 2 (July), Fig. 3 (August) and Fig. 4 (October).

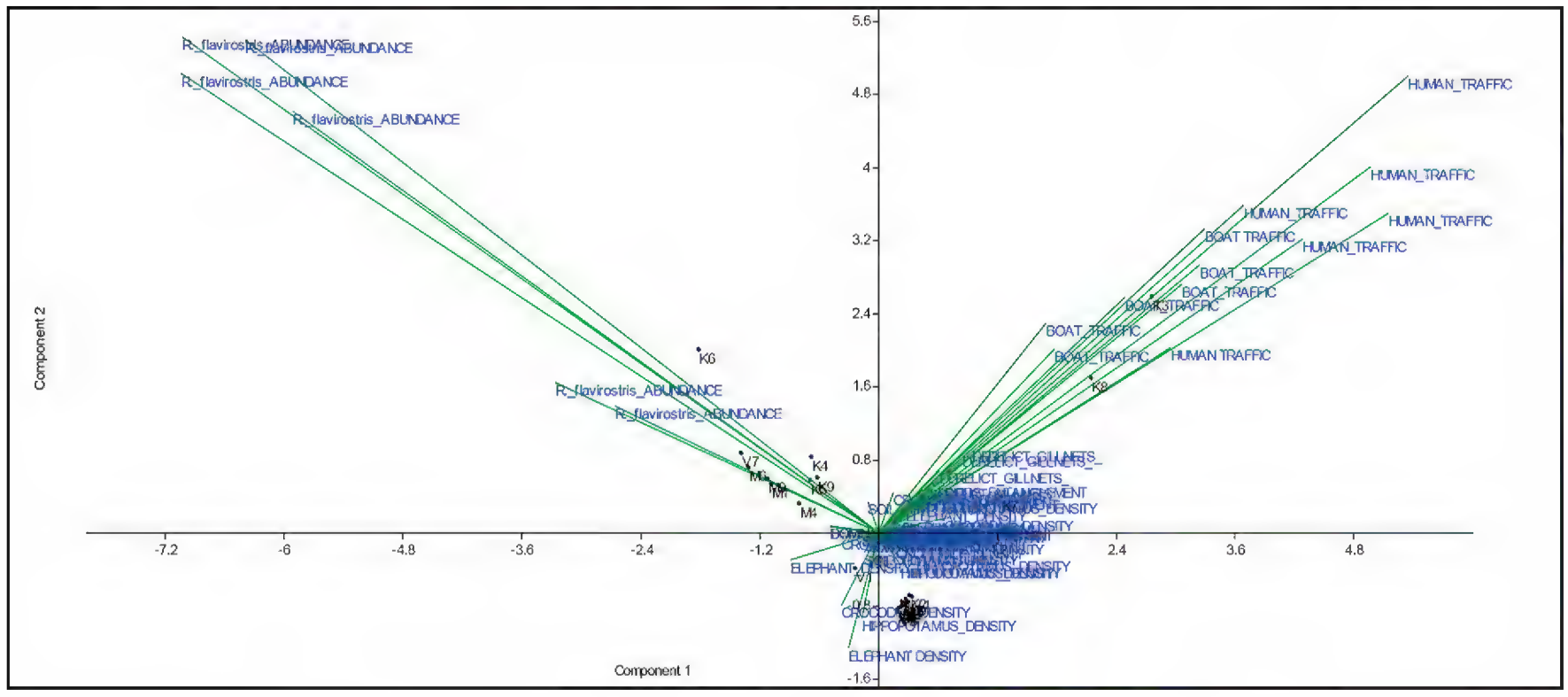
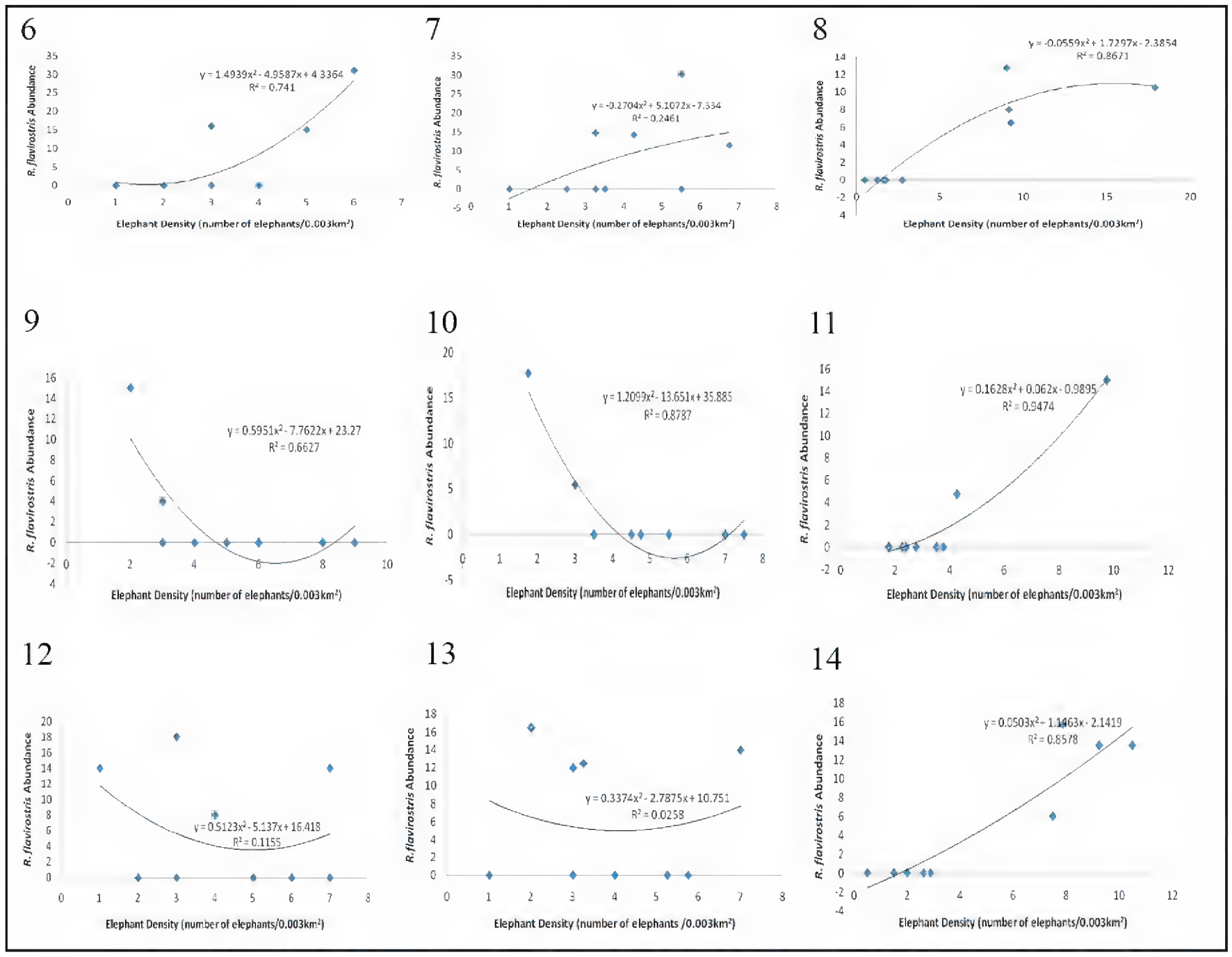


Figure 5. Principal Component Analysis (PCA) biplot of habitat factors on sandbars in Lake Kariba, and along the Zambezi River upstream and downstream of Lake Kariba.



Figures 6–14. Polynomial function fitting of the relationship between elephant density and *Rynchops flavirostris* abundance at sampling sites in the lentic and lotic habitats of the Zambezi Valley, Zimbabwe (Fig. 6: Lake Kariba sites in July; Fig. 7: Lake Kariba sites in August; Fig. 8: Lake Kariba sites in October; Fig. 9: Upstream sites in July; Fig. 10: upstream sites in August; Fig. 11: upstream sites in October; Fig. 12: downstream sites in July; Fig. 13: downstream sites in August; and Fig. 14: downstream sites in October).

there was no statistically significant three way interaction between section of the Zambezi Valley, sampling month and hippopotamus density on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). There was also no statistically significant interaction between hippopotamus density and sampling month, as well as between hippopotamus density and section of the Zambezi Valley ($p>0.05$; Three-way ANOVA). Tukey's pair wise comparisons showed significant difference ($p<0.05$) in hippopotamus density between Kariba and the upstream habitat. However, no significant difference was observed in hippopotamus density between Lake Kariba and downstream environs. Significant difference ($p<0.05$) in hippopotamus density was also observed between upstream and downstream habitats. Two sample t test showed no significant differences ($p>0.05$) in hippopotamus density between sites occupied by *R. flavirostris* and those unoccupied by the species in all three sections of the Zambezi Valley throughout all the sampling months.

In all the sampling months, crocodile density did not vary significantly ($p>0.05$; One-way ANOVA) among the three sections of the Zambezi Valley. There was also no statistically significant three way interaction between crocodile density, section of the Zambezi Valley, and sampling month on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). No statistically significant interaction was observed between crocodile density and sampling month, as well as crocodile density and sec-

tion of the Zambezi Valley ($p>0.05$; Three-way ANOVA). Tukey's pair wise comparisons showed no significant difference ($p>0.05$) in crocodile density between habitats within the Zambezi Valley. Two sample t test also showed no significant differences ($p>0.05$) in crocodile density between sites occupied by *R. flavirostris* and those unoccupied by the species in all the three sections of the Zambezi Valley throughout all the sampling months.

Derelict gillnets were not encountered within the lotic habitats of the Zambezi Valley throughout the sampling period, but were present at all sampling sites in Lake Kariba. Derelict monofilament gillnets were observed at all sampling sites in Lake Kariba throughout the sampling period. These were associated with artisanal fishing that was prominent along the Kariba Town Shoreline. Significant strong positive correlation ($r > 0.6$; $p < 0.05$) was observed between human traffic and density of derelict gillnet within the lake. Significant strong positive correlation ($r > 0.6$; $p < 0.05$) was also observed between boat traffic and density of derelict gillnet within the lake. Two sample t test showed significant differences ($p<0.05$) in density of derelict gillnet between sites occupied by *R. flavirostris* and those unoccupied by the species in Lake Kariba across the sampling months. Sites occupied by *R. flavirostris* had significantly higher density of derelict gillnet and human traffic than those unoccupied by the species.

One-way ANOVA showed that across the three months sampled, human traffic varied significantly ($p<0.05$) among the three sections of the Zambezi Valley. Artisanal fishing was the most common human activity at sampling sites in Lake Kariba. On the contrary artisanal fishing was rare at sampling sites upstream and downstream of Lake Kariba. Scenic viewing by tourists was the most common human activities along the Zambezi River both in the upstream and downstream habitats of Lake Kariba. Tests for effects of interactions revealed absence of statistically significant three way interaction between human traffic, section of the Zambezi Valley, and sampling month on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). There was also no statistically significant interaction between human traffic and sampling month on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). However, significant effect on *R. flavirostris* abundance ($p<0.05$; Three-way ANOVA) was observed on interaction between human traffic and section of the Zambezi Valley. Tukey's pair wise comparisons showed significant difference ($p<0.05$) in human traffic between the lentic and lotic environs of the Zambezi Valley. Lake Kariba had significantly higher human traffic compared to the lontic environs. However, human traffic did not vary significantly ($p<0.05$) between upstream and downstream environs of the Zambezi Valley. Two sample test also showed no significant differences ($p>0.05$) in human traffic between sites occupied by *R. flavirostris* and those unoccupied by the species in upstream and downstream environs throughout all sampling months. Significant differences ($p<0.05$) were observed in human traffic between sites occupied by *R. flavirostris* and those unoccupied by the species only in Lake Kariba throughout the sampling months.

Boat traffic also varied significantly ($p<0.05$; One-way ANOVA) among the three sections of the Zambezi Valley over the entire sampling period. Turkey's pair wise comparisons showed significant difference ($p<0.05$) in boat traffic between the lentic and lotic habitats. Lake Kariba had significantly higher boat traffic than the lotic environs of the Zambezi River, both upstream and downstream of the lake. However, no significant difference ($p>0.05$) was observed in boat traffic between upstream and downstream habitats. Tests for effects of interactions revealed absence of statistically significant three way interaction between boat traffic, section of the Zambezi Valley and sampling month on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). There was also no statistically significant interaction between boat traffic and sampling month, as well as boat traffic and section of the Zambezi Valley ($p>0.05$; Three-way ANOVA). Two sample t test showed no significant differences ($p>0.05$) in boat traffic between sites occupied by *R. flavirostris* and those unoccupied by the species in upstream and downstream habitats throughout all the sampling months. Boat traffic also showed no significant difference ($p>0.05$) between sites occupied by *R. flavirostris* and those unoccupied by the species in Kariba in July. However, significant differences ($p<0.05$) were observed in boat traffic between sites occupied by *R. flavirostris* and those unoccupied by the species in Lake Kariba environs in August and October.

Dominant Habitat Substrate

Three types of dominant habitat substrate, namely predominantly sandy substrate, predominantly silty substrate, and predominantly sandy with pebbles substrate were observed at sandbars in Lake Kariba and along the Zambezi River channel. Predominantly sandy substrate had the highest frequency of occurrence at sampling sites (45% in Lake Kariba and in upstream habitats; 56% in down-stream habitats).

Significant difference ($p<0.05$, One-way ANOVA) was observed on *R. flavirostris* abundance among the three types of dominant habitat substrate in all the three sections of the Zambezi Valley. In both the lentic and lotic habitats of the Zambezi Valley, *R. flavirostris* showed most preference of predominantly silty substrate at perching sandbars to the other two habitat substrates. In all the three months sampled, predominantly silty sandbars scored the highest suitability indices in Lake Kariba and in habitats upstream and downstream of the lake (Figs. 18–20). However, *R. flavirostris* also showed to a lesser extent some preferential selection of predominantly sandy substrate in all the three sections of the Zambezi Valley (Figs. 18-20). No *R. flavirostris* was observed on predominantly sandy with pebbles substrate in all the three sections of the Zambezi Valley (Figs. 18–20) implying no preference of this habitat within the entire valley.

Tests for effects of interaction revealed that there was no statistically significant three way interaction between section of the Zambezi Valley, sampling month and dominant substrate on *R. flavirostris* abundance ($p>0.05$;Three-way ANOVA). However, significant effect of interactions on *R. flavirostris* abundance ($p<0.05$; Three-way ANOVA) were observed between sampling month and dominant substrate as well as between section of the Zambezi Valley and dominant substrate.

Substrate Moisture Content

Significant difference ($p<0.05$; One-way ANOVA) was observed on *R. flavirostris* abundance among sites with different soil moisture content in all the three sections of the Zambezi Valley. Results revealed that *R. flavirostris* showed no preference of dry habitat substrate for perching in all the three sections of the Zambezi Valley. The species preferred wet and/or moist substrate in all the three sections of the Zambezi Valley (Figs. 21–23).

There was no statistically significant three way interaction between section of the Zambezi Valley, sampling month and soil moisture content on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). No significant interaction was also observed between sampling month and soil moisture content on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). However, significant interaction effect on *R. flavirostris* abundance ($p<0.05$; Three-way ANOVA) was observed between section of the Zambezi Valley and soil moisture content. In Lake Kariba environs, the species showed most preference of moist habitat substrate for perching. However, the species also utilised wet habitat substrate within the lentic environs of Lake Kariba. A similar pattern was observed in upstream habitat where the species showed most preference to moist substrate. Preference levels for wet habitat substrate were low in upstream environs and varied across the three sampling months in the three sections of the Zambezi Valley (Figs. 21–23). On the contrary, although *R. flavirostris* utilised moist habitat substrate for perching downstream of Lake Kariba and upstream environs, the species showed highest preference of wet habitat substrate throughout the three sampling months downstream of the lake. Habitat suitability index was low ($Ya< 0.5$) for moist habitat substrate throughout the three sampling months in downstream habitat and was high ($Y_a >0.5$) for wet habitat substrate (Fig. 24).

Substrate Temperature

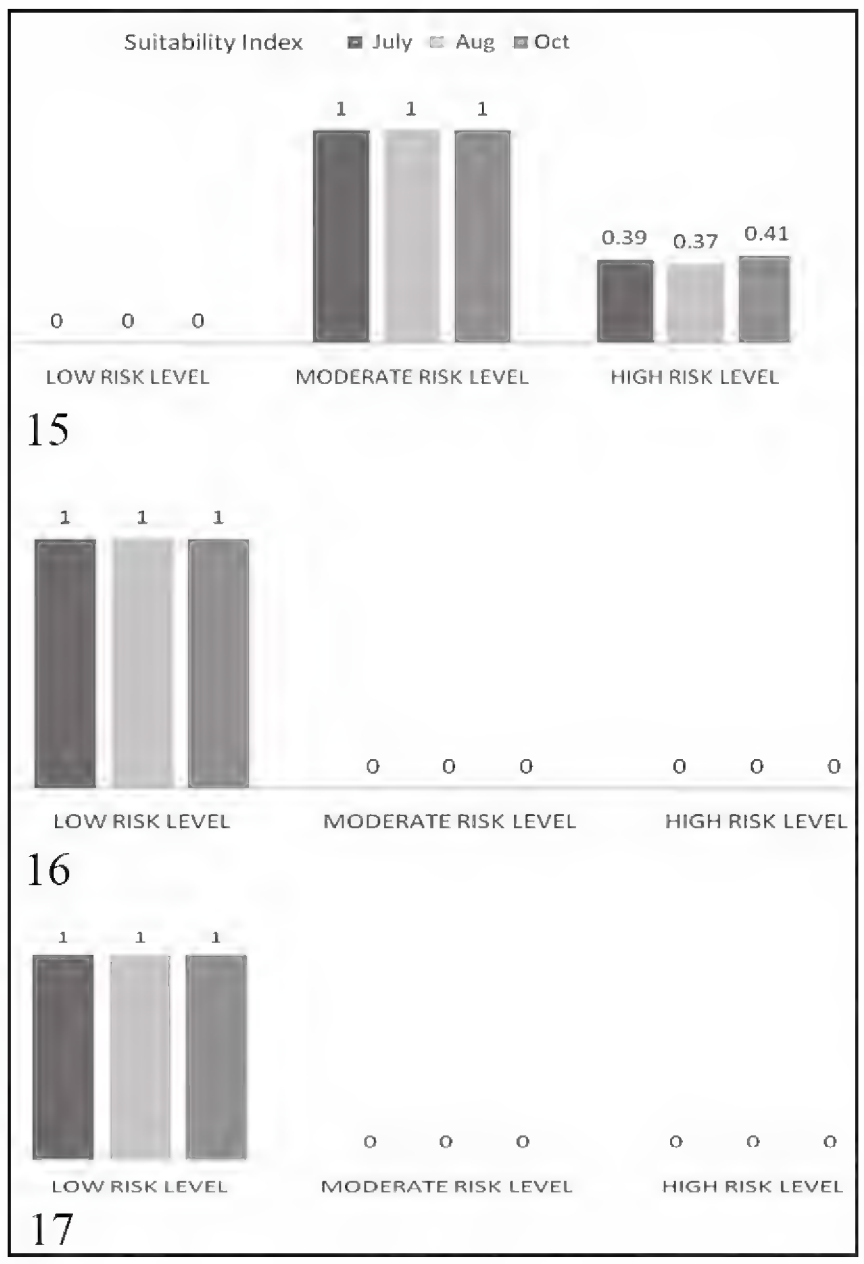
In all the three sections of the Zambezi Valley *R. flavirostris* displayed narrow preference of temperature ranges throughout the sampling months. No significant difference ($p>0.05$; One-way ANOVA) was observed in substrate temperature of sandbars occupied by *R. flavirostris* in all the three sections of the Zambezi Valley. In all the three sections of the Zambezi Valley, the species showed preference to substrate temperature below 26°C in July, with highest preference temperature index at the 22–24°C range in Lake Kariba and in upstream environs, and highest preference temperature index at the 24–26°C range in downstream environs of Lake Kariba. In August, *R. flavirostris* showed

preferential selection of the 26–30°C substrate temperature range in all the three section of the Zambezi Valley, with highest preference temperature index at the 28–30°C temperature range (Table 5). *R. flavirostris* preferentially selected 30–32°C temperature range in Lake Kariba and in habitats upstream and downstream of the lake. The species also showed tolerance to high substrate temperature range of 32–34°C in all the three sections of the Zambezi Valley during the month of October. However, *R. flavirostris* showed no preference of substrate temperatures >34°C in all the three sections of the Zambezi Valley (Table 5). Two sample t test showed no significant differences ($p>0.05$) in soil temperature between sites occupied by *R. flavirostris* and those unoccupied by the species in all the three sections of the Zambezi Valley throughout all the sampling months.

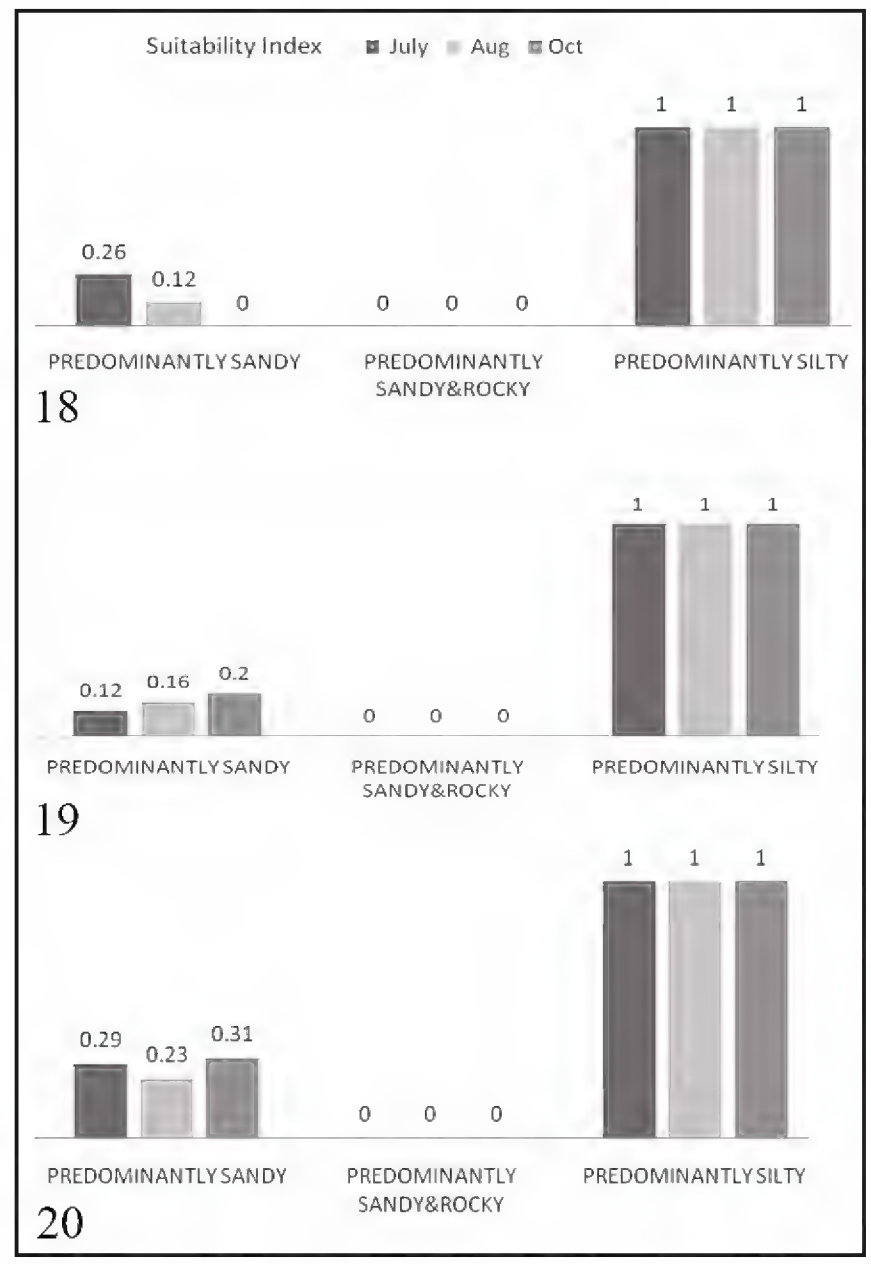
Tests for effects of interaction revealed that there was no statistically significant three way interaction between section of the Zambezi Valley, dominant substrate and soil temperature on *R. flavirostris* abundance ($p>0.05$; Three-way ANOVA). There was also no significant effect of interactions ($p>0.05$; Three-way ANOVA) observed between soil temperature and dominant substrate on *R. flavirostris* abundance within the Zambezi Valley.

Food Availability

In Lake Kariba, significant strong positive correlation was observed between food abundance and *R. flavirostris* abundance at sampling sites ($r > 0.6$; $p < 0.05$). *Rynchopus flavirostris* showed preferential selection of sandbars with high food abundance (sites K4, K5, K6 and K9). *R. flavirostris* preferen-



Figures 15–17. Habitat risk suitability criteria for *Rynchops flavirostris* in the lotic and lentic environment of the Zambezi Valley Zimbabwe (Fig. 15: Kariba; Fig. 16: Upstream habitat; Fig. 17: Downstream habitat). See also in the text.



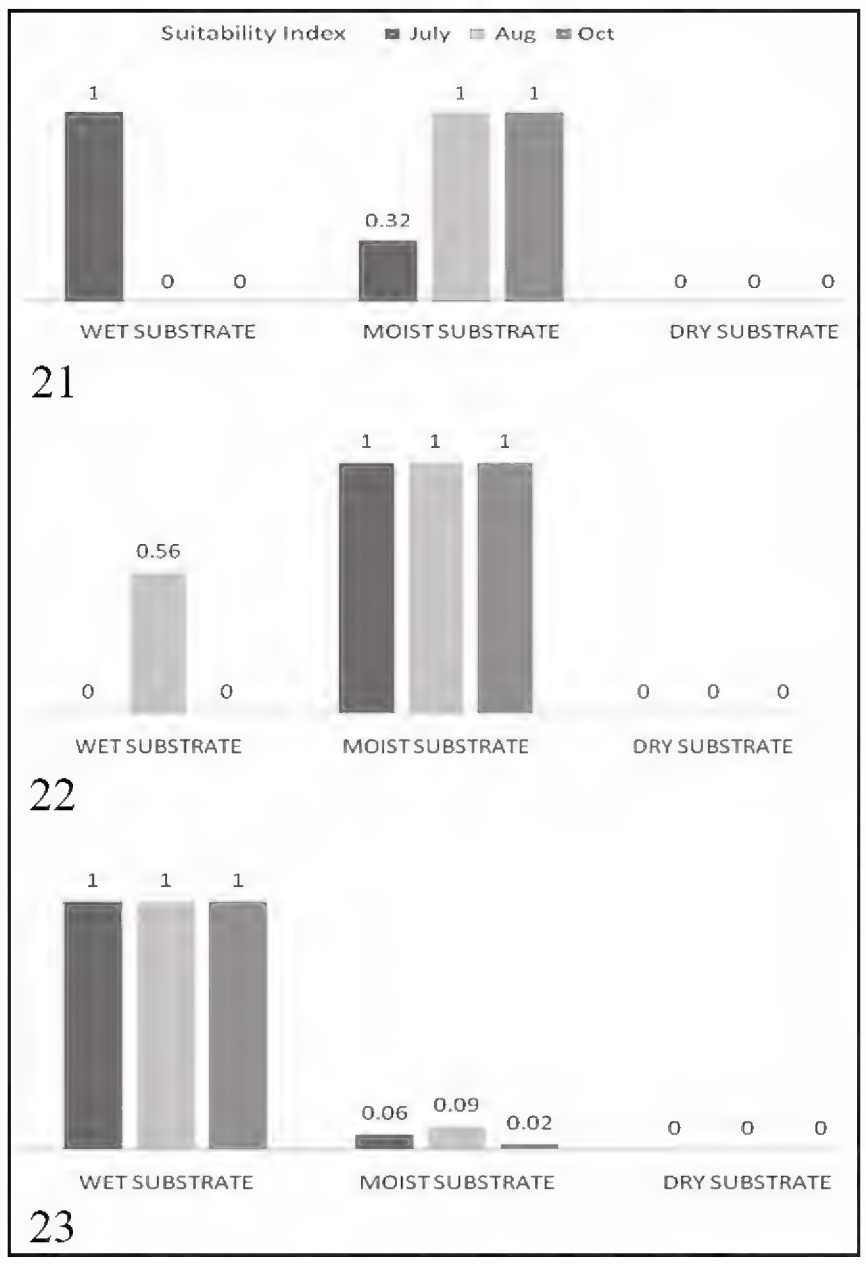
Figures 18–20. Dominant substrate suitability criteria for *Rynchops flavirostris* in the lotic and lentic environment of the Zambezi Valley Zimbabwe (Fig. 18: Kariba; Fig. 19: Upstream habitat; Fig. 20: Downstream habitat). See also in the text.

tially selected sandbars with food abundances greater than 0.15 fish/m^2 (Figs. 24, 25). Highest habitat suitability index was recorded at food abundance of 0.2–0.25 fish/m^2 category. Two sample t test showed significant differences ($p<0.05$) in food abundance between sites occupied by *R. flavirostris* and those unoccupied by the species.

Significant strong positive correlation ($r > 0.6$; $p < 0.05$) was also observed between food abundance for *R. flavirostris* and human traffic at sampling sites in Lake Kariba. Human traffic was high at sampling sites with high food abundance for *R. flavirostris* and low at sampling sites with low food abundance.

DISCUSSION

Contrary to Coppinger et al. (1988) who reported on likely absence of *R. flavirostris* within Lake Kariba some two decades after construction of the lake, contemporary investigations more than fifty years after construction of the lake revealed its presence and breeding in the lake and along the Zambezi River. These results are consistent with observations by Rost et al. (2006) who argued that although disturbance alters habitats and causes species extirpation, microenvironment modification over time may facilitate adaptation and gradual return of old species into the altered environment. Thus, the presence of *R. flavirostris* in Lake Kariba more than fifty years after construction of Lake Kariba could be attributed to re-establishment of suitable habitats for the species within the lentic environs. As highlighted by Donnelly (1984), changes in Kariba environs will continue to take place, facilitating changes in species composition in the lake



Figures 21–23. Substrate moisture level suitability criteria for *Rynchops flavirostris* in the lotic and lentic environment of the Zambezi Valley Zimbabwe (Fig. 21: Kariba; Fig. 22: Upstream habitat; Fig. 23: Downstream habitat). See also in the text.

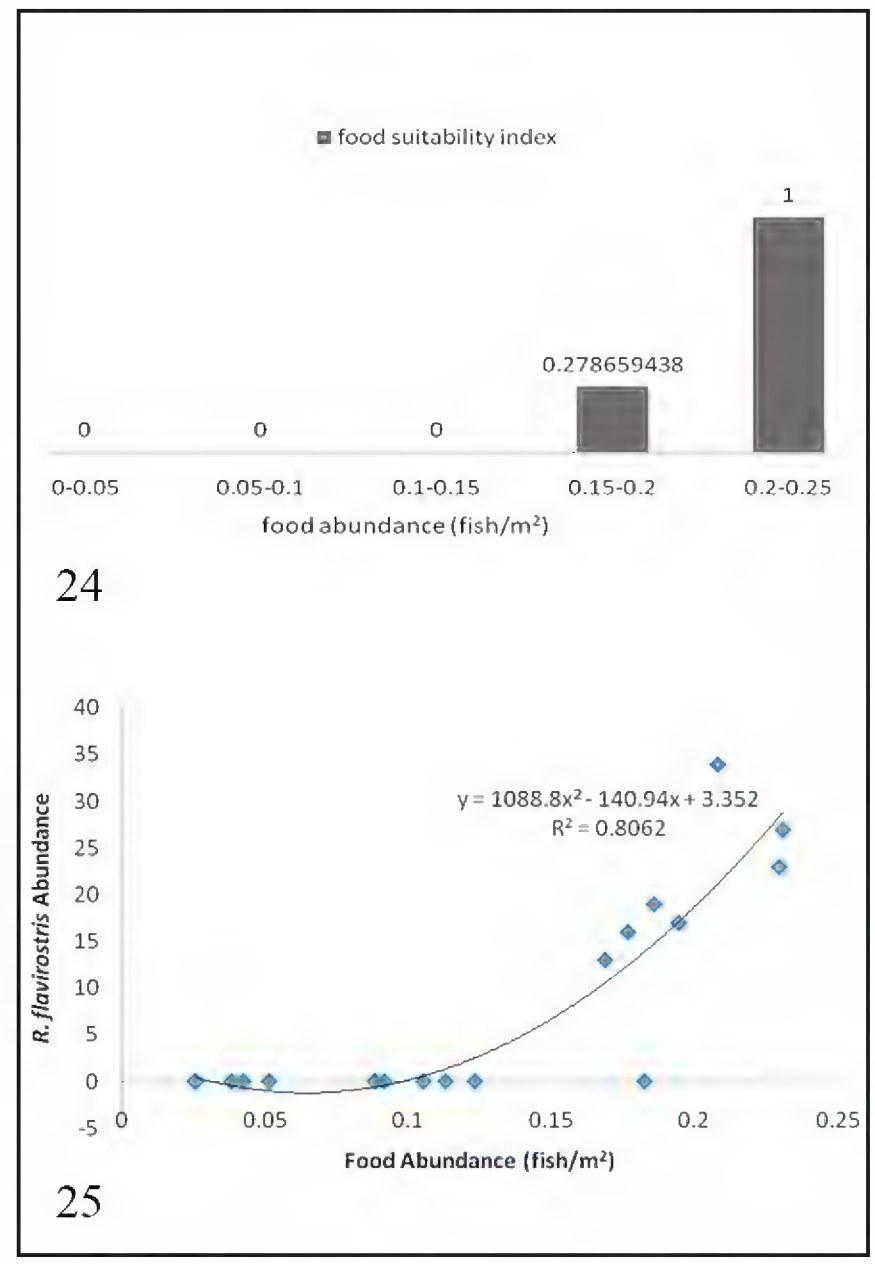


Figure 24. Food abundance suitability criteria for *Rynchops flavirostris* in Lake Kariba. Figure 25. Polynomial function fitting of *R. flavirostris* abundance across the range of food abundance at sampling sites in lentic habitat of Lake Kariba.

over time. However, contemporary distribution of *R. flavirostris* within the lake appears to be restricted to some sites along the shoreline. In the present study, *R. flavirostris* was only observed on selected sites along Kariba Town shoreline. Recent surveys were only conducted on Lake Kariba and associated islands. Thus the results may not conclusively ascertain a restricted distribution of the species within the lake.

Contemporary results reported cases of breeding of *R. flavirostris* within all three sections of the Zambezi Valley in Zimbabwe. However, only few isolated cases provided evidence of *R. flavirostris* reproduction within the three sections. This suggested that the species rarely breeds within the Zambezi valley, thus ascertaining its vulnerability in Zimbabwe. *R. flavirostris* breeds from July to October in Zimbabwe (Maclean, 1985). Thus, even if we failed to observe any nesting colonies during our surveys which coincided with the breeding season for the species, we at least should have observed a significant number of juveniles in all three sections of the Zambezi Valley. *R. flavirostris* has conspicuous nesting behavior, and failure to observe any active nesting colonies or nesting behavior indicates that breeding has not fully recovered for the species in Zimbabwe, more than fifty years after construction of Lake Kariba. Interestingly, breeding of *R. flavirostris* was also low upstream of Lake Kariba where we assumed that construction of the lake had no impact on the species habitat. In situations like this, development of habitat suitability criteria for *R. flavirostris* in different sections of the Zambezi Valley was crucial for a proper habitat assessment.

Several studies demonstrated that habitat suitability criteria may differ among different types of habitats (Jowett, 2002). This justifies our effort to develop site specific habitat suitability criteria for *R. flavirostris* within the three sections of Zambezi Valley, where the species was observed to specialise in lentic and lotic environs. Literature indicates that *R. flavirostris* breeds on broad rivers and lakes where it occupies large, dry sandbars that are largely free of vegetation (Urban et al., 1986; del Hoyo et al., 1996). Contemporary investigation showed that dominant substrate varied on sandbars in the Zambezi Valley, and this influenced habitat selection by *R. flavirostris* in the lotic and lentic environs of the valley. No comprehensive studies to develop *R. flavirostris* substrate suitability criterion within the Zambezi Valley had ever been carried out prior to this study. Thus no baseline data were available for comparison. Our results showed that *R. flavirostris* preferentially selected predominantly silty and predominantly sandy substrates. Substrate that was predominantly sandy and rocky was not necessarily suitable for the species in all three sections of the Zambezi Valley. Significant interactions were observed between sampling month and dominant substrate as well as among sections of the Zambezi Valley and dominant substrate in influencing *R. flavirostris* abundance. This can be attributed to fluctuations in water levels in Lake Kariba, as well as fluctuations in river volume and river velocity on the Zambezi River during different sampling months. These fluctuations most likely influenced substrate deposition on sandbars in the aquatic habitats of the Zambezi Valley.

Just like all migratory species, *R. flavirostris* is an intra-African migrant whose habitat selection is influenced by habitat stability. As suggested by Pollard (1989), *R. flavirostris* can migrate and repeatedly occupy a stable sandbank for several years only to abandon the habitat when conditions become unfavourable. Changes in water level emanating from dam construction were suggested by several authors to be altering habitat quality for *R. flavirostris* in the Zambezi Valley (Pollard, 1989; Eriksson, 1990; Tree, 1988, 1992; Wood & Tree 1992). Lake Kariba, like most lentic habitats, is characterised by large fluctuations of water level (Eriksson, 1990). This influences substrate deposition at emergent sandbars and associated islands. The lake traps silt which normally ends up as sandbars that are utilised by *R. flavirostris* when water level recedes (Nugent, 1983, 1988). However, stability of these sandbars as habitat for sandbank nesters is influenced by cyclic fluctuations of water levels in Lake Kariba. Similarly, substrate deposition, formation of sandbars and stability of sandbars as suitable habitat for *R. flavirostris* along the Zambezi River are influenced by temporal and spatial fluctuations in river volume and velocity. Catchment input from the Zambezi River tributaries most likely influences river flow rate and formation of sandbars along the river upstream of Lake Kariba, while water flow controls at Kariba Dam wall influences volume and velocity of the Zambezi River downstream of the lake. Tree (1988) and Riddle

(2009) highlighted that Lake Kariba had significant effect on river velocity and structure of the Zambezi River bed downstream of the lake. Thus fluctuations in river volume and velocity upstream and downstream of the lake is likely to have significant impacts on trends in quantity and quality of sandbars as habitats for *R. flavirostris* along the Zambezi River channel. Comprehensive studies are necessary to verify this.

Our soil moisture level results contrasted with those of Urban et al. (1986) and del Hoyo et al. (1996) who stated that *R. flavirostris* occupies and breeds on dry sandbars. Our results were consistent with those of Tree (1992) who highlighted that *R. flavirostris* requires slightly damp substrate to maintain coolness around the eggs. Coppinger et al. (1988) reported on some breeding colonies situated on dry, moist and wet substrates. In the contemporary distribution, *R. flavirostris* showed preferential selection of wet and moist habitats. In the current study, no records were made of *R. flavirostris* occupying dry sandbars. In fact, within the three month sampling period of the present study, the species was frequently observed resting in water edges in both the lentic and lotic environs of the Zambezi Valley. Preference of wet substrate was highest downstream of the lake which happens to be the hottest among the three sections of the Zambezi Valley sampled. Standing in water and occupying wet and damp substrates could be the species behavioural adaptation to cope with the intense heat experienced in the Zambezi Valley. Behaviour plays an important role in thermoregulation among birds. Birds often stand in water to regulate their body temperature and to prevent hyperthermia in hot and dry environments.

R. flavirostris response to risk factors varied between the lentic and lotic habitats. In the lotic environs, the species preferentially selected sandbars of low risk index and completely avoided sandbars with moderate to high risk indices. This behaviour was expected given that habitat selection by organisms is also influenced by refuge from predation and other risks. Contrary to this, *R. flavirostris* occupied sandbars of moderate and high risk in Lake Kariba. The species was observed to occupy sandbars with high human traffic despite literature suggesting that the avian species is usually wary and unapproachable (Maclean, 1985). Contemporary results suggest *R. flavirostris* high tolerance for people in Lake Kariba. This association could be explained by variation in food availability at sandbars along the lake shoreline. Contemporary results showed that sandbars with high food abundance were also selected as human fishing grounds. Lake Kariba supports artisanal fishing, and it would be expected that fishing activities and human traffic would be high at sandbars with high fish production. In this case, optimum foraging behaviour of *R. flavirostris* in Lake Kariba was likely to be influenced by trade-offs between averting risk and starving or tolerance to human presence and gaining energy. Some degree of species tolerance to human presence was thus adopted by *R. flavirostris* in order to gain energy in the lentic environs. However, this tolerance most likely impacted negatively on breeding success of *R. flavirostris* in Lake Kariba.

In conclusion, the present study revealed that food availability, dominant substrate type, soil moisture level and habitat risk emanating from both natural and anthropogenic factors at sandbars were important determinants of vulnerability and adaptive capacity for *R. flavirostris* in the Zambezi Valley. We noted that Zambezi River volume and velocity upstream and downstream of Lake Kariba and standards of management of the lake flood gates could possibly be affecting the size and stability of suitable habitat for *R. flavirostris*. Selection of sandbars with varying habitat conditions by *R. flavirostris* highlighted the need for further research on factors influencing stability of sandbars in the entire Zambezi Valley from north western Zambia to the Indian Ocean. Such research is critical for generation of comprehensive data sets that are required for analysis of vulnerability and adaptive capacity of *R. flavirostris* in its Zambezi territory, and for proper formulation of conservation strategies for the species in the region.

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Quantification of two metallic elements in the Mullet, *Mugil cephalus* Linnaeus, 1758 (Perciformes Mugilidae), fished at the bay of Oran (NW Algeria)

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ABSTRACT

Aware of the problem of marine pollution, the Algerian authorities and the national scientific community are increasingly interested in environmental studies, with a view to assessing risks and protecting our coastal ecosystem. For this reason, several studies are carried out on the studies of the degree of contamination of the Algerian coasts as well as the fishery products. This research is partly rooted in a monitoring mission to conduct an integrated study of the marine environment. The objectives of this work are oriented towards societal questions and to provide elements of assistance to the management of this environment for the local actors. This study focused on the evaluation of the concentrations of the two heavy metals Lead (Pb) and Zinc (Zn) in Mullet, *Mugil cephalus* Linnaeus, 1758 (Perciformes Mugilidae), caught in the Oran bays. This fish reflects very well the quality of its biotope; it is a very abundant species in Algerian coastal waters and very appreciated by the Algerian consumer. The harvesting campaigns were carried out for fourteen months from February 2012 to March 2013, the quantification of heavy metal concentrations was carried out in three organs: liver (the detoxification organ), gonads (the reproductive organs) and flesh (representing the part consumed by humans). Heavy metal concentrations were determined by Flame Atomic Absorption Spectrophotometry as a function of several parameters. The mean concentrations of Lead and Zinc in muscle, liver and fish gonads in Oran Bay are below standards, i.e. the grades are generally low in the two metals studied and do not exceed the normative limits required in fish. This study indicates a limited bioavailability of two metals (Lead and Zinc) in the fishery products. Results of biochemical analysis revealed metallic contents below the maximum allowable doses (D.M.A), which other studies have confirmed. These heavy metals are present at low concentrations in nature and in living organisms.

KEY WORDS marine pollution; fishing products; heavy metals; *Mugil cephalus*; Oran Bay.

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INTRODUCTION

Ensuring the safety of food of animal origin, offered to consumers, is one of the priority concerns of food safety. Nowadays, and for this purpose, many preventive and repressive programs are regularly carried out in the national sphere and internationally.

Given the industrial and human activities, several compounds and toxic elements are thrown into the marine environment, causing deterioration in the quality of marine waters, nuisance in aquatic organisms, and especially a threat to human health. In this study we found it necessary to raise awareness of the most feared pollutants for the marine environment and their involvement in the bioaccumulation phenomena in food chains and beyond to raise the importance of knowledge about biochemical risks and marine pollution to preserve human health and environmental quality.

It has become essential to monitor the quality of the marine environment, especially since it alone covers 71% of the planet's surface. Monitoring programs require targeted monitoring and controls, limited over time to identify infringements and non-conformities. Also, to take corrective measures to establish an adequate control plan (Baghdadi, 2012).

Aquatic environments are today the receptacle of effluents and industrial and urban waste often toxic to living organisms (Taleb & Boutiba, 2007).

Contamination of fish requires monitoring and analysis of potentially hazardous toxic elements. These metallic elements have natural trace components of the aquatic environment, but their levels have increased due to several activities (industrial, agricultural and mining). As a result, fish are exposed to high levels of these metallic elements (Ünlü & Ümgüm, 1993; Kalay & Canli, 2000).

This study constitutes a first non-exhaustive approach to better know through the fish the state of contamination of the natural environment and to provide answers to the questions raised by the laboratory study of the network of environmental monitoring of Oran-Algeria (LRSE).

Some heavy metals are essential in minimal amounts for normal growth and development of these fish such as zinc, and others do not have biological significance such as lead (Nemesok & Hughes, 1988; Kalay & Canli, 2000).

Monitoring of metal concentrations in the environment does not provide direct information on bioavailable concentrations in ecosystems and understanding of contamination processes. It is in this context that Goldberg (1975) proposed monitoring contaminant concentrations in living organisms, such as fish to monitor environments and their levels of contamination. It is the principle of "quantitative bio-indicators" based on the fact that marine organisms accumulate contaminants (Garrigues et al., 2002). It is in this context that we chose our coastal species, *Mugil cephalus* Linnaeus, 1758 (Perciformes Mugilidae) which is located in the study area (Medifaune, 2002); this type of fish is also appreciated by the population of the Algerian coast.

For other references see Goldberg et al. (1978), Denton & Burdon-Jones (1981), Legorburu et al. (1988), Attrassi & Saghi (1992), Yilmaz (2003) and Yadav et al. (2012).

MATERIAL AND METHODS

Study area

The Algerian basin is located to the south-western Mediterranean basin between latitudes 35°00.00' and 40°00.00' N and longitudes 2°00.00' and 7°00.00' W and 45°00.00' E. It is located east of the Alboran Sea, between Algeria to the south, the Balearic Islands in the north-west and north-east of Sardinia (Benzohra & Millot, 1995). The Bay of Oran (Fig. 1) is located in north-west of Algeria and south-west of the Mediterranean, it belongs to the coastal mountains Tel-Septentrional (Jebel Murdjadjo and Khar) (Leclaire, 1972). The coast of Oran is bordered by cliffs which are located, in particular, at Cape Falco (Boutiba, 2007). It occupies the central part of the Oranan coastline and opens from west to east; it is bordered on 30 km of elevated land and draws a semi-circular almost regular from Cape Falcon to Cape Aiguille.

Figure 1. Geographical position of the study area: the Bay of Oran (Belhoucine et al., 2014)

Sample collection

The samples were taken along the Oran Bay by calling local fishermen and harvesters directly after entering the harbor. Harvesting campaigns were carried out monthly for 14 months from February 2012 to March 2013. Each harvest consists of 10 to 15 samples, harvesting of the fishes is done so that the samples are diversified by different sizes and weights , In order to be able to reflect the variation of the concentrations of the metal elements present in their environments. The samples used for the determination of the heavy metal content were packed in plastic bags and kept in a cooler equipped with Pb storage batteries. The samples were sent directly to the Environmental Monitoring Laboratory (LRSE) of the Department of Biology at the University of Oran for sample preparation and subsequent analysis.

Each sample was placed in an individual packaging guaranteeing its integrity and bearing an identification code ensuring its traceability. It was also be accompanied by a sampling form.

Sample processing

The destination laboratory is initially responsible for preparing the samples (Homogenization and constitution of the samples to be analyzed).

The aim of this section is to describe the method for the determination of heavy metals in mugil by atomic absorption spectrophotometry. The principle of the method consists firstly in wet mineralization because any search for a mineral toxicant fixed in the organs always requires mineralization which results in a complete degradation of the organic matter (Amiard et al., 1987). We have opted for wet mineralization because it minimizes the loss of volatile organometallic compounds during drying (FAO, 1977), followed by an atomic absorption spectrophotometric assay (Casas et al., 2007; Ghanjaoui, 2009; Boumehres, 2010).

In order to obtain a homogeneous solution, the protocol used can be summarized as follows:

Weigh 1 g of fresh sample into the tube.

Add 1 ml Concentrated Nitric Acid.

Select the program for a temperature of 95 °C for one hour.

Cooling of the mineralizer by a water pump.

Fill or adjust the sample to 4 ml with distilled water.

The final solution is poured into the Atomic Absorption Spectrometry (SAA) buckets which allow the detection of low levels of metals and mineral elements in the solutions.

Statistical analysis

All the data was collected according to the matrices studied in Excel files and then processed with the software Statistica. To compare the mean concentrations of heavy metals according to several parameters (organs, sex, months), an analysis of variance was applied to test the influence of the variables (season and year).

The Student t-test (Testing Expectations of Equalities: Two Observations of Equal Variance) was used to estimate the magnitude of the differences in concentrations of metal pollutants.

The purpose of the analysis of the variance is to test the presence of significant or not significant differences between averages. This analysis is applied to estimate the contribution of each factor to the variance of the dependent variable.

The purpose of the Principal Component Analysis (ACP) is to summarize the data structure described by the quantitative variables, while obtaining correlated or uncorrelated factors.

RESULTS AND DISCUSSION

Variations of the percentages of the average concentrations of heavy metals present in the sample

The coastal marine environment has a certain specificity compared to other environments: it is the ultimate receiving environment for terrestrial pollution (the biologically richest area), and the environment where numerous activities are developed (fishing and marine cultures, tourism, etc.). This medium is therefore vulnerable to a multitude of exogenous substances (Mahyaoui et al., 1989; Boumehres, 2010). Today, marine biodiversity is weakened by various types of pollutants (Moukrim et al., 2000; Banaoui et al., 2004; Marchand, 2008; El Morhit, 2009). Chemicals are among the pollutants involved in the erosion of marine biodiversity. In this case, flora and fauna can be considerably impoverished not only quantitatively, but also qualitatively (Ramade, 1993; El Morhit, 2009).

The analyses revealed the presence of very heterogeneous values of trace metales. The most important contamination concerns zinc, which represents 94%, as opposed to lead contamination, which represents 6% (Figure 1). The level of heavy metals in the different species depends mainly on dietary habits (Amundsen et al., 1997; Romeo et al., 1999; Mormede & Davies 2001; Watanabe et al., 2003).

According to other authors, differences in metal concentrations are related to feeding and eating habits of benthic and pelagic fish species (Bustamente et al., 2003). Our species is a demersal detritivore regularly feeding on zooplankton mainly from industrial chemical releases, dead plants detritus, fish, crustaceans and Algae (Farrugio, 1975; Blaber, 1976; Tung, 1981; Cardona, 2000).

Bustamente et al. (2003) showed that benthic fish usually accumulate higher concentrations of heavy metals than pelagic fish. IIt is important to underline that there areseveral industrial areas (Sonatrach, Chemecal ammoniac industries, and water purification stations) around the study site, which leads to the existence, in the marine environment, of trace elements which are transported to the ecosystems by atmospheric means (ie direct diffusion into the air) and through water currents (Arnac & Lasssus, 1985; Maanan et al., 2004; Marchand, 2008).

The presence of Lead in coastal ecosystems is mainly due to a strong anthropogenic influence (Sunda, 1989; Vasquez et al., 1994; Boumehres, 2010).

The high concentration of zinc is probably related to the presence of the Zinc electrolysis factory in Ghazaouet which is part of Algeria's northwestern coastline; this factory uses seawater for the cooling of the sulfuric acid manufacturing facilities and certain facilities of the central thermal power factory. Water, which has been used for various purposes, is directly discharged into the sea (Bakalem, 1980).

Content of the heavy metals analyzed in the fish studied (in ppm of the wet weight):

Table 1 shows the concentrations of the two pollutants accumulated in *M. cephalus*. The Zinc concentrations range from 6 part(s) per million (ppm) to 25.9 ppm of the fresh weight of *Mugil cephalus*, our results are confirmed by other similar works (Bat et al., 2012; Bouhadiba et al., 2015).

In addition, lower Lead concentrations were found between 1.02 ppm and 0.5 ppm, as also proved by Yilmaz (2008).

These results are in agreement with the experiments in the field of bioaccumulation of heavy metals in the organs of the species which is the subject of our experiment carried out at the LRSE (Environmental Monitoring Network- University of Oran1: Bouhadiba et al., 2015), this is similar for other species studied in the same laboratory: *Osilinus turbinatus* (Von Born, 1778) (Belhaouari et al., 2011) and *Merluccius merluccius* Linnaeus, 1758 (Belhoucine, 2014); the same is at the international level for other *Mugil* species (Uluozlu et al., 2007; Bat et al., 2012).

We found significant differences between Zinc and Lead concentrations (Statistica, $p < 0.05$).

Moreover, no trace above the detection threshold was found in the flesh of the individuals analyzed for Zinc. For Lead, all sampled sectors show little inter-individual variation.

Comparison of the heavy metal contents in Mugil cephalus *with respect to the maximum permissible doses (D.M.A)*

The values recorded in Table 2 show that the mean concentrations of Zinc and Lead are not very high respect to the Eligible Maximum Dose standards and therefore cannot cause acute toxicity.

Variation of the average concentrations according to the organs of Mugil cephalus

Analysis of metals in the three organs (ie, gonads, liver and muscle) shows a gap between the maximum zinc and minimum lead concentrations (Figure 2). Lead, a toxic metal, has many sources and is generally present in small quantities (Harrison et al., 1981; Rooney et al., 1999; El Morhit, 2009; Bouhadiba et al., 2015). The highest levels could be attributed to releases from industries loaded into this element that may be in the vicinity of these sites.

The Zinc concentrations recorded in the three organs are higher in the gonads than in the liver and muscle, respectively (24.08 ppm, 13.93 ppm and 13.85 ppm). On the other hand, it was found that

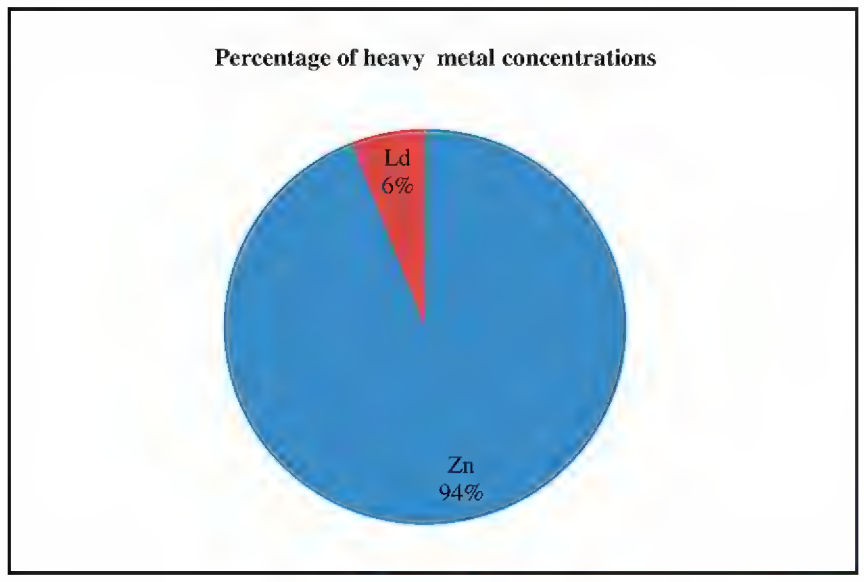

Figure 2. Changes in the percentages of mean concentrations of heavy metals in the sample.

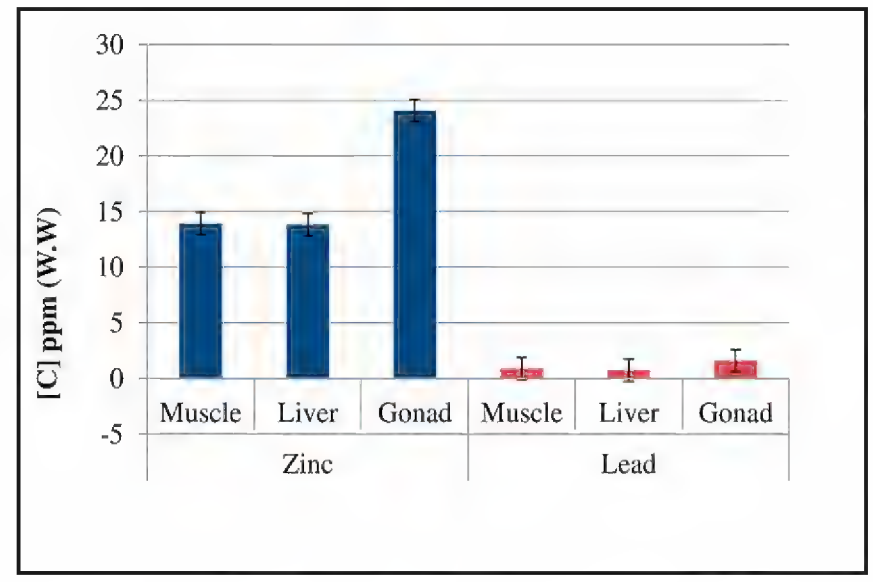

Figure 3. Variation of the mean concentrations of Zinc and Lead (ppm of w.w.) as a function of the organs of *Mugil cephalus*.

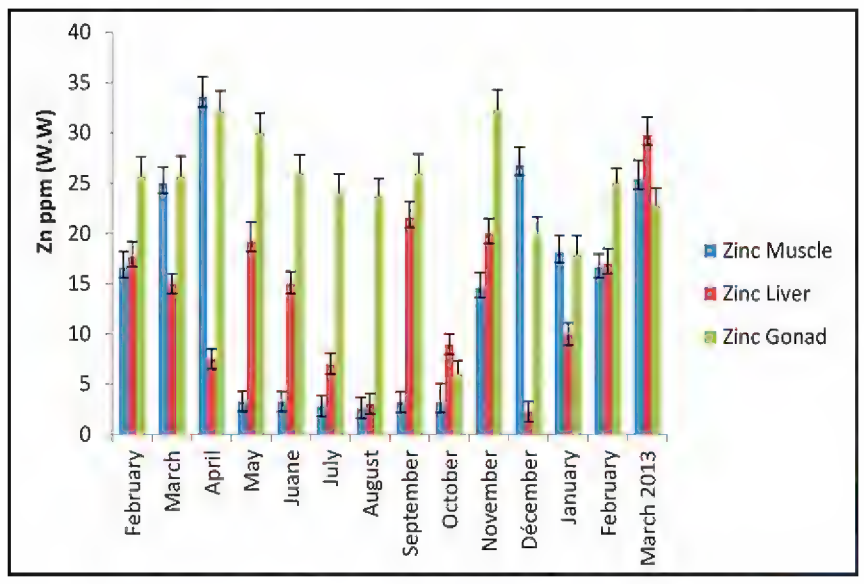

Figure 5. Monthly assessment of mean concentrations of Zinc (ppm of W.W.) in *Mugil cephalus*.

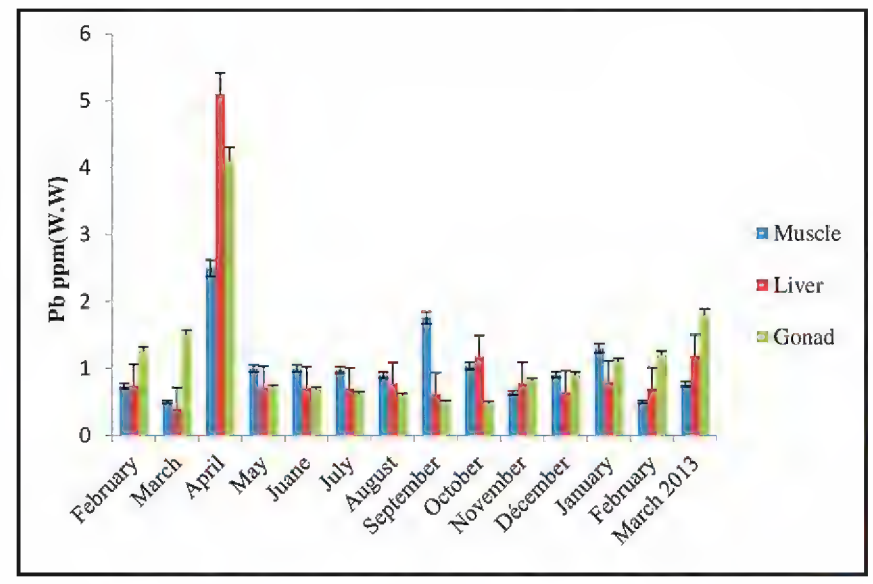

Figure 6. Seasonal variation in mean concentrations of lead (ppm of W.W.) in *Mugil cephalus*.

the differences in Lead concentrations at the three organs are low, which is of the order of (1.61 ppm) for the gonads, of (0.91ppm) for the muscle and (0.76 ppm) for the liver.

The high concentrations of Zinc recorded are explained by the fact that this element is essential in the metabolism of the cells in the enzymatic reactions as cofactor (Adeyeye et al., 1996).

In the literature, the authors state that fish meat usually has the lowest potential for accumulation of heavy metals, while the liver and kidneys have the highest potential (Lafaurie et al., 1981; Lafaurie, 1982; Hilmy et al., 1983; Dallinger et al., 1987; Chen & Chen, 1999), this data coincides with the results obtained in our *Mugil* species. Other studies have shown that heavy metals accumulate mainly in metabolic organs such as the liver which stores metals to detoxify by producing metallothioneins (Kargin & Erdem, 1991; Olsson, 1996).

The results of this study confirm that there are significant correlations between the concentrations of the two heavy metals.

This study presents a spatio-temporal evaluation of the chemical contamination of fishery products by determining the heavy metal content (Maanan et al., 2004; Glasby et al., 2004). The presence of Lead and Zinc in coastal ecosystems is mainly evidence of anthropogenic influence (Sunda, 1989; Vasquez et al., 1994; Boumehres, 2010).

Monthly assessment of mean heavy metal concentrations (ppm of W.W.) in Mugil cephalus

The levels of monthly variation of the metallic trace elements recorded are present in all organs and throughout the year. Size and sex parameters were not considered. Rise and fall episodes were recor-

ded in metallic trace element concentrations. Gonads accumulate more heavy metals than other organs.

1. Monthly evaluation of mean concentrations of Zinc (ppm of W.W.) in *Mugil cephalus*.

The highest mean concentration of Zinc is observed in April with the respective values of gonads, liver and muscle. There was also a significant drop in concentrations at the three organ levels in October.

2. Monthly assessment of mean concentrations of Lead (ppm of W.W.) in *Mugil cephalus*.

The rate of lead appears to be relatively homogeneous throughout the year, with the exception of April where Lead concentrations are high in the three organs (liver, gonad, muscle, 5.1, 4.1, 2.5 ppm). The accumulation of Lead in April is more intensive in the liver. The decrease in Lead was remarkable in May for the three organs (0.72, 0.72, 1 ppm, respectively).

The period of sexual resting of fish is a phase of gametogenesis which is characterized by an increased accumulation of nutritive reserves and stored in the form of carbohydrate, lipid and protein materials (Webb, 1979), and during the period of the laying, these nutrient reserves are drawn. Automatically the heavy metal concentrations fall (release of metals at that time) and the accumulation of reserves will resume slowly only at the beginning of the period of sexual rest (Webb, 1979).

In the Mediterranean, the different populations of *M. cephalus* reproduce between June and October (Faouzi, 1938; Erman 1959; Morovic 1963; Farrugio 1975; Brusle & Brusle, 1977; Brusle, 1981). Which confirms the fall in heavy metal concentrations in specific months during the year.

Seasonal evaluation of mean heavy metal concentrations (ppm of W.W.) in Mugil cephalus

1. Seasonal evaluation of mean heavy metal concentrations (ppm of W.W.) in *Mugil cephalus*.

Figures 6 and 7 illustrate an increase in metallic trace elements during the spring season, and its resuming in autumn, which is consistent with the same results of the studies that assert that seasonal variation in grades depends on the season. Higher levels are recorded in spring and autumn (Essadaoui & Sif, 2001).

2. Study of the relationship: Lead and Zinc/ season by ACP (Analysis in Main components).

The projection of the two sampling seasons on the factorial plane (1 × 2) made it possible to identify three distinct groups. In terms of the inertias of the factorial axes of the ACP, the F1 axis accounts for 64.89% of the point cloud information (lead and zinc concentrations according to the seasons) and the F2 axis only provides 35.11 % of information about the similarity between the concentrations of the seasons. The quadrants of the factorial plane make it possible to group the concentrations of the seasons to be compared and the axes divide them into groups and subgroups.

The projection of the variables of the different concentrations of lead and zinc obtained during the

		Mugil cephalus
Zinc	M±E	16.107±5.6
	i-x	6-25.9
Lead	M±E	1.020±0.75
	i-x	0.5-1.02

Table 1. Content of the heavy metals analyzed in the fish studied (in ppm of the Wet weight). M: medium, E: Standard deviation, i: Minimal, X: Maximal.

	Lead	**Zinc**
***Mugil cephalus* (present study)**	1.02 m ppm W.W.	16.10 ppm W.W.
fishes	0.3 - 6 ppm dry.weight (b) 0.5 ppm W.W. (f)	5 mg/g dry.weight (g)

Table 2. Comparison of heavy metal contents in *Mugil cephalus* with respect to the maximum permissible doses (M.P.A). (b) GIPPM, 1973; (f) CSHPF, 1990; (G) NHMRC, 1992.

four seasons is divided into three distinct groups. The two selected factor plots F1xF2 or the inertia rate is 64.35%. The group1 of the positive axis groups together winter 2013 and winter 2012 or the concentrations ranges between 10.65 and 10.87 in ppm of W.W.

Group 2 consists of spring with concentrations of 10.36 ppm of W.W., the third group represents summer and autumn 2012 of the negative side of the factorial axis whose concentrations are respectively 6.73 and 7.87 ppm of W.W.

The results of the seasonal assessment of mean heavy metal concentrations show more than a significant spatial distribution over time. The seasonal variation in the concentration of heavy metals was studied in several Revisions (Philips, 1976, Denton & Burdon-Jones, 1981). However, the results show that the grades vary according to the harvesting period (Mousataid et al., 2005) and seem to depend on the harvest season.

3. The variation of Zinc and Lead concentrations during the sampling period.

The average zinc concentration range is larger than that of lead during the seasonal seasons of sampling, which shows that there is a highly significant difference between seasonal variations in relation to the two heavy metals; 25.9 ppm (zinc) and 1.02 ppm (lead).

***Monthly change in mean concentrations of heavy metals as a function of sex in* Mugil cephalus**

On the basis of the results of figure 10, we can say that the bioaccumulation of the two pollutants is more significant in the male than in the female.

Mean concentrations by sex indicate that the accumulated organic zinc is greater in males than females. This can be explained by the fact that females draw their nutritional reserves by synthesizing the latter in carbohydrate, lipid and protein materials at the time of egg lying during the summer period.

In the case of Lead, it has a low concentration in both sexes and in all organs.

According to Al-Yousuf et al. (1999) and Canli & Atli (2003), there are factors such as gender and height that can influence the bioaccumulation of heavy metals.

Thus, Powell et al. (1981) had already demonstrated that heavy metals were concentrated in the organs of teleost fishes in decreasing order: Liver> Kidney> flesh.

The t test of Student demonstrated that there is no significant difference between the accumulation of the two heavy metals in male and female subjects.

One of the main results obtained in this study is the demonstration of various concentrations of Zinc and Lead in the mugil on the Bay of Oran. The hypothesis of pollution of the Oran Bay of industrial origin had been put forward to explain the presence of these metals at high concentrations. Our study thus provides a new element of comparison. This study indicates that for Zinc and for Lead, similar concentrations were observed in all fish sampled at the same sampling sites. Information on the con-

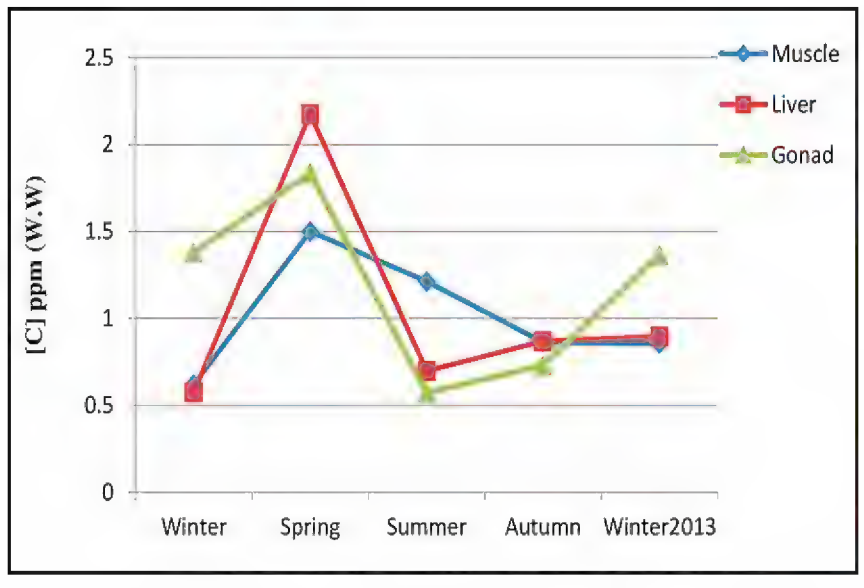

Figure 6. Seasonal variation in mean concentration of lead (ppm of W.W.) in *Mugil cephalus*.

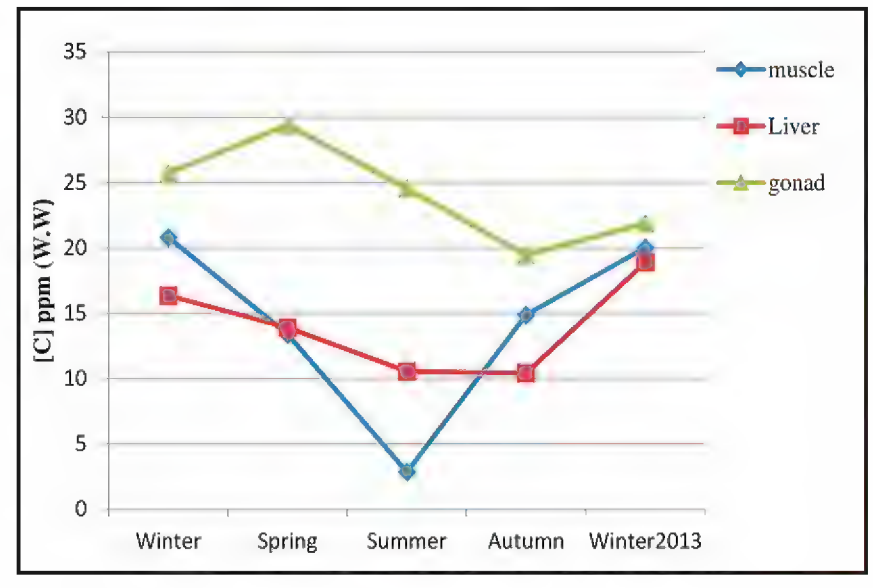

Figure 7. Seasonal variation in mean concentration of zinc (ppm of W.W.) in *Mugil cephalus*.

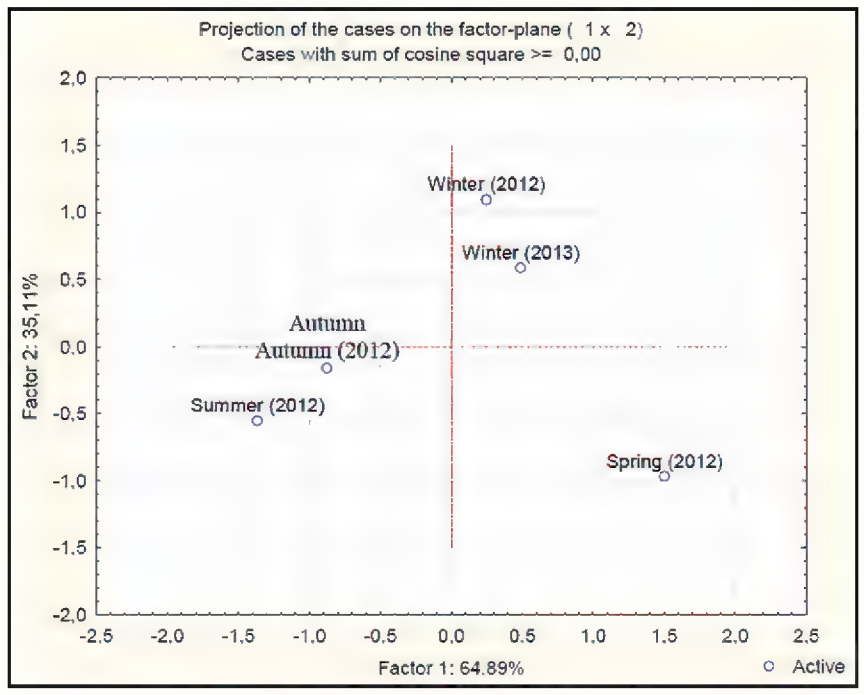

Figure 8. Projection of the sampling seasons in the factorial plane F1xF2.

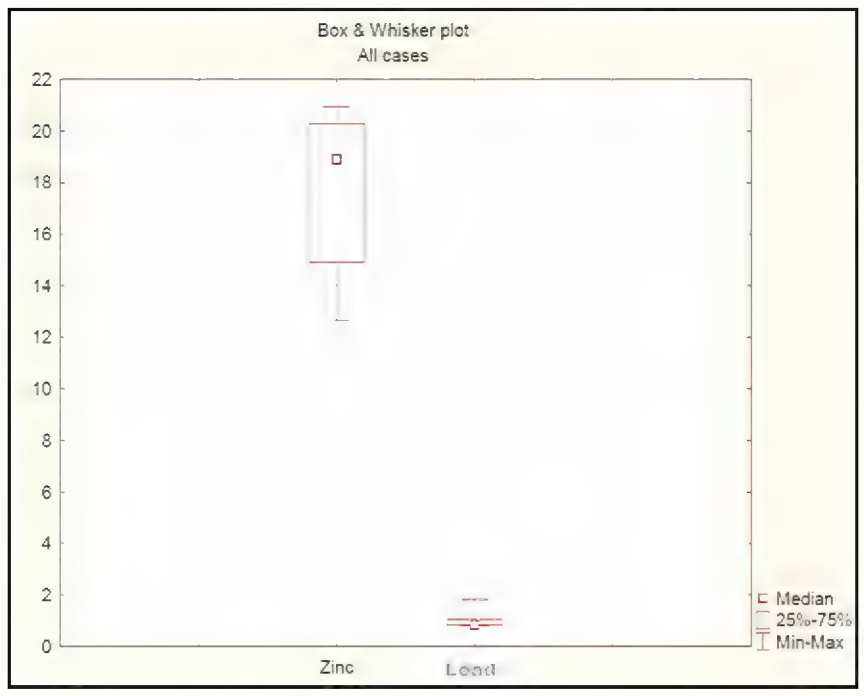

Figure 9. Diagram of the variation of Zinc and Lead concentrations during the sampling period.

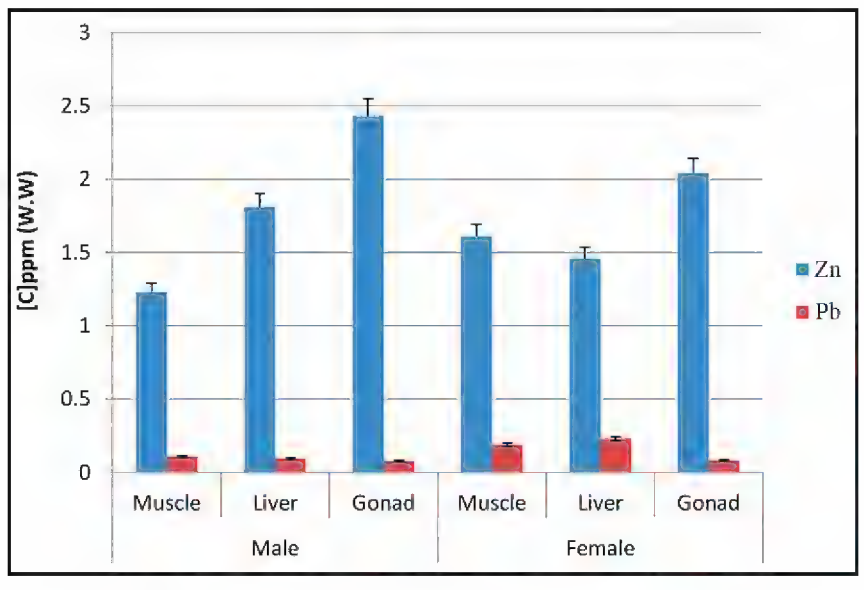

Figure 10. Monthly change in mean concentrations of heavy metals (Lead, Zinc) as a function of sex in *Mugil cephalus*.

centrations of metals in fish is still too fragmentary to be able to know precisely their origin. However, similar levels observed at several geographically distant sites and located on different basins are in favor of a hypothesis of more general contamination origin and not of several local origins. On the other hand, they suggest that industrial chemical activities are the main source of contamination (Baghdadi, 2012).

It also seems probable that the source of the metals found in the fish analyzed in our study is not only the direct pollutant discharges into the Bay but is more related to industrial pollution.

CONCLUSIONS

In Algeria, studies have been carried out on the determination of metallic levels in fish taken from the Mediterranean coast.

The risks of bioavailability and toxicity of these traces metals are feared, as they constitute permanent dangers for the whole food chain and threaten public health (Arnac & Lassus, 1985; Fadil et al., 1997; Boumehres, 2010). As man is the final element of consumption of marine products and being the last phase in the food chain and as this species is highly appreciated by the Algerian consumer; we performed this chemical analysis to demonstrate the level of contamination of metallic elements in fish and at the sampling site.

This allowed us to conclude that the concentrations are below the limit values for fish proposed by FAO (1983). High levels of heavy metals have been observed in the liver and gonads. Although fish liver and gonads are very rarely consumed by humans.

Overall, the interpretation of the results is made difficult by the absence of reference data concerning the concentrations of metals present in fish in natural environments not subject to the effects of anthropization. Our objective was to complement the LRSE study on the search for sources of metallic pollution in the Bay of Oran, to evaluate the quantification of heavy metals in fishes.

The analysis of flesh and gonads and liver of *M. cephalus* makes it possible to assess the state of contamination of the whole food chain and to assess

whether this contamination represents a potential risk for human consumption.

The various analyses carried out made it possible to obtain the following elements:

No significant direct impact of the metal releases found in the LRSE study could be observed on the different fish.

No trace of Lead was detected beyond the quantification threshold.

A generalized presence of Zinc in the analyzed parts of fish and lead at equivalent levels in all the sectors studied was highlighted.

The metal content in the flesh does not appear to pose a risk to human consumption due to the large quantities of fish that must be ingested to reach the acceptable doses.

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A new genus (Orthoptera Acrididae Acridinae) and three species of short-horned grasshoppers from India

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ABSTRACT A new genus *Keshava* n. gen. (Orthoptera) of the subfamily Acridinae (type species *Keshava shishodensis* n. sp.) with three new species are described from Chhattisgarh, India. Taxonomical notes are provided.

KEY WORDS Taxonomy; Keshavpur; Acridoidea; new genus; new species.

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INTRODUCTION

The subfamily name Acridinae (Orthoptera) was first used by Krauss (1890) but priority for family - group names based on *Acrida* dates from Acridina Macleay, 1821 (Eades et al., 2017).

Presently, the subfamily Acridinae is represented by 140 genera globally (Eades et al., 2017), of which 15 genera and 36 species reported by Shishodia et al. (2010) from India. Recently, Kumar & Usmani (2015) described a new genus *Mesophlaeoba* Kumar et Usmani, 2015 with the type species *M. usmanii* Kumar et Usmani, 2015 from Himachal Pradesh, India.

The subfamily Acridinae is characterized by head of variable shape, prosternal process usually absent, wings often present, intercalary vein of medial area of elytron usually present, tympanal normally present; posterior margin of female subgenital plate entirely setose.

The present paper deals with the description of a new genus of this subfamily with three new species from India; additional taxonomical notes are provided.

MATERIAL & METHODS

Study area

The survey was carried out in Durg district of Chhattisgarh state and two protected areas i.e. Barnawapara Wildlife Sanctuary and Udanti Wildlife Sanctuary (Fig. 1). The Durg district is situated south-eastern part of the state and lies between latitude 20°54'N to 21°32"N and longitude 81°10'E to 81°36"E, covering an area of about 8549 sq. kms. Barnawapara Wildlife Sanctuary, Raipur district of Chhattisgarh is located between latitudes 21°18'45" to 21°30'N and longitudes 88°22'30" to 82°37'30"E, with an area of about 244.66 sq. km. Udanti Wildlife Sanctuary is located in the south-western part of earlier Raipur district which is now furcated into Gariyaband district. The area of the Udanti Wildlife Sanctuary is about 247.80 sq. km.

Sampling

The specimens were preserved and pinned. The figures were captured using Nikon D 300S with 105

macro lens. The specimens were studied under Leica stereo-zoom Microscope (Leica M205 A). All the measurements are given in millimeters. The type specimens are deposited in the Central Entomological Laboratory (CEL) of the Zoological Survey of India, Kolkata.

RESULTS

Systematics

Ordo ORTHOPTERA Olivier, 1789
Subordo CAELIFERA Ander, 1939
Superfamilia ACRIDOIDEA Macleay, 1821
Familia ACRIDIDAE Macleay, 1821
Subfamilia ACRIDINAE Macleay, 1821
Tribe ACRIDINI Macleay, 1821
Genus *Keshava* gen. nov.
Type species: *Keshava shishodensis* n. sp.

Keshava n. gen.

DIAGNOSIS OF NEW GENUS. Size medium. Antenna subfiliform, fastigium of vertex concave, without median carina, lateral carinae elevated; Disc of pronotum punctuate with two transverse sulci, median carinae and lateral carinae distinct or indistinct, anterior margin of pronotum straight and posterior margin rounded or obtuse angulate. Cerci sylender, ovipositor valve short and stout.

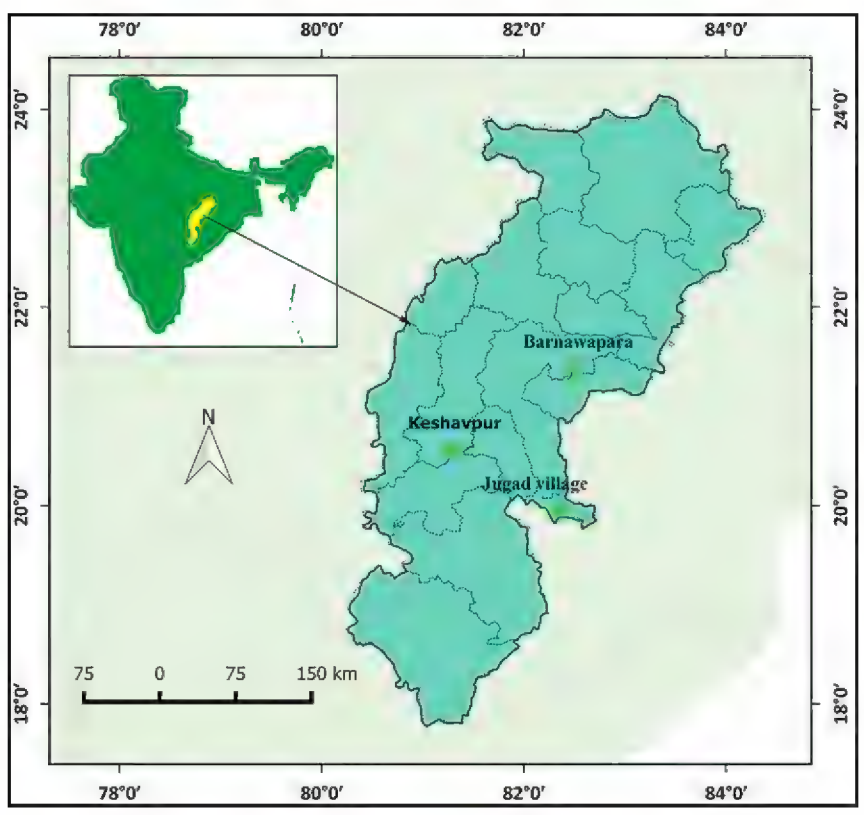


Figure 1. Collection localities in Chhattisgarh, India.

ETYMOLOGY. The name of the genus has been given after the collection locality.

REMARKS. *Keshava* n. gen. differs from the other genera of the subfamily Acridinae i.e. *Acrida* Linnaeus, 1758 and *Truxalis* Fabricius, 1775 from elongated head and hind legs. The new genus differs from the other known genera *Phlaeobida* Bolivar, 1902, *Paraphlaeoba* Bolivar, 1902, *Carliola* Uvarov, 1939, *Paradontomelus* Ramme, 1929, *Odontomelus* Bolivar, 1890 and *Zygophlaeoba* Bolivar, 1902 by the presence of fully developed tegmina which is short or rudimentary in all the above genera. *Pasiphinus* Bolivar, 1914 differs from new genus by the presence of longitudinal ridge on head and pronotum together. The genera viz. *Sikkimiana* Uvarov, 1940, *Gymnobothrus* Bolivar, 1889, *Julea* Bolivar, 1914 and *Duroniopsis* Bolivar, 1914 are different from new genus by the presence of curved lateral carinae of pronotum in prozona. Lateral carinae of pronotum diverging in metazona in genera viz. *Phlaeobacris* Williamse, 1932, *Holopercna* Karsch, 1891 and *Orthchtha* Karsch, 1891 make them different from new genus. *Pyrgophlaeoba* Miller, 1929 and *Babaabuddinia* Bolivar, 1918 differ from new genus by the irregular lateral carinae of pronotum. Genus *Neophlaeoba* Usmani et Shafee, 1983 differs from new genus by presence of fastigial foveolae. Genus *Mesophlaeoba* Usmani et Kumar, 2015 differs by presence of filiform antennae and hind tibiae with dark pale colour.

For others data see Linnaeus, 1758; Fabricius, 1775; Bolivar, 1889, 1890, 1902, 1914, 1918; Krauss, 1890; Karsch, 1891; Macleay, 1821; Miller, 1929; Ramme, 1929; Willemse C., 1932; Uvarov, 1939, 1940; Usmani & Shafee, 1983.

Keshava shishodensis n. sp. (Figs. 2–9)

EXAMINED MATERIAL. Holotype female DC, Chhattisgarh, Durg, Keshavpur, 06.II.2014, 20°33’25.3”N, 81°18’59.4”E, 400 m, coll. S.K. Gupta, Reg. no. 18834/H5.

Paratype: 12 females DC, same locality as holotype data, Reg. no. 18835/H5-18846/H5.

DESCRIPTION OF THE HOLOTYPE. Female. Body size medium, head broad, obtuse, anterior margin in profile slightly concave, shorter than pronotum in dorsal view. Fastigium of vertex slightly concave, lateral carinae elevated, median carina indis-

tinct. Foveolae invisible. Frontal ridge subparallel, coarsely punctured, below broad. Eyes oval, about 1.8 times as long as wide; located near anterior part of fastigium of vertex. Pronotum 1.5 times as long as wide; pronotal disc, rugose, punctured without complete transverse sulci. Median carinae slightly developed in metazona. Lateral carinae absent. Metazona 1.3 times longer than prozona. Mesosternal lobe 1.6 times wider than long. Wings: tegmina and hind wing well developed, exceeding upto hind knee of hind femora, apex obtuse. Abdomen 2.2 times longer than its width; Cerci cylindrical, 2 times longer than wide, tip rounded, shorter than epiproct. Ovipositor: Valvula short, end slightly hook shaped, Lower valvula shorter than upper one. Ovipositor dorsal valve stout rather ventral valve short. Fore leg with short white hairs; femur 4.6 times as long as wide, femur subequal with tibia. Mid leg with short white hairs; femur 5 times as long as wide, femur 1 time longer than tibia. Hind femora elongated, about 3.8 times as long as wide, reaching end of abdomen. Hind tibiae slender, shorter than hind femur with small white hairs and 10 outer and 9 inner spines. First tarsal segment slightly shorter or subequal to second and third tarsal together. Colour: body light brown. Hind tibiae with a large yellowish hue near apical part.

Measurements (all in millimetres). Body length: 22.232 (from the tip of the vertex to the end of the abdomen), Compound eye length: 1.006, width: 0.544; interocular distance: 0.694; fastigium of vertex length: 0.647; fastigium of vertex width: 0.555; head length 1.709; Pronotum length: 2.206, width: 1.409; prozona length: 0.947, metazona length 1.259, mesosternal lobe length: 0.751, width 0.462; Fore leg: femur length: 1.691, width: 0.361; tibia length: 1.699, width: 0.224; tarsus length (by segments) I: 0.300, II: 0.179, III: 0.496; claw length: 0.300. Mid leg: femur length: 2.141, width: 0.414, tibia length: 2.091, width: 0.221; tarsus length: I: 0.387, II: 0.151, III: 0.490; claw length 0.346. Hind leg: femur length: 6.19, width: 1.608, tibia length: 5.802, width: 0.301, tarsus length: I: 0.754, II: 0.207, III: 0.658, claw length 0.786. Abdomen length: 6.237; width: 2.568. cerci length 0.657, width 0.312, dorsal ovipositor valve length: 1.096; ventral Ovipositor valve length: 1.039.

VARIABILITY. The paratypes have no substantial morphological differences with the holotype described. Length of body 22 mm.

ETYMOLOGY. This species is named in honour of a renowned Indian Orthopteran taxonomist, Dr. M. S. Shishodia, Retd. Scientist, Zoological Survey of India.

Keshava barnawaparensis n. sp. (Figs. 10–17)

EXAMINED MATERIAL. Holotype, female, Chhattisgarh, Barnawapara Wildlife Sanctuary, Barnawapara, 07.VII.2011, 21°24'002"N, 82° 25' 313"E, altitude 301 m, coll. S.K. Gupta, Reg. no. 18847/H5.

Paratype: 8 females, Same data as holotype, 18848/H5- 18855/H5.

DESCRIPTION OF THE HOLOTYPE. Female. Body medium sized, cylindrical, antennae slightly flattened basally, 22 segmented, longer than head and pronotum together; head subconical, shorter than pronotum; eyes oval in shape; maximum diameter of eye slightly longer than the interocular distance; frons oblique; fastigium of vertex angulate; slightly produced in front of eyes, median carina of vertex interrupted, lateral carina elevated, apex obtusely rounded; face oblique in profile view, frontal ridge narrow deeply sulcate below, lateral carinulae diverging downwards. Pronotum 1.6 times as long as wide, disc with two transverse sulci interrupted with median carina, with well developed lateral carinae and median carinae in metazona distinct and in prozona obliterated; surface of pronotum usually punctuate, anterior margin of pronotum straight and posterior margin curved; prozona 1.3 times longer than metazona; posterior margin of metazona rounded. Prosternal process absent. Mesosternal lobe 1.3 times shorter than its width. Mesosternal interspace open. Tegmina: tegmina and hind wing well developed, reaching upto tip of hind knee; hind wings slightly shorter than tegmina. Legs: hind femora short and compressed laterally, upper and lower carina smooth, reaching upto the tip of abdomen ; hind tibiae slender with outer 11 and inner 10 small spines at dorsal margin. First tarsal segment 2.1 times longer than second tarsal segment and also slightly longer than third tarsal segment. Abdomen 4.8 times longer than its width; Cerci cylindrical, 1.7 times longer than wide, tip rounded, shorter than epiproct. Ovipositor: valvula short, end slightly hook shaped, lower valvula shorter than upper one. Ovi-

positor dorsal valve stout rather ventral valve short. Colour: body light brown. Pronotum lateral view with a dark blackish brown stripe both side. Tibiae with upper part yellow and after all part dark blackish. Hind tibial spines yellowish with tip dark blackish.

Measurements (all in millimetres). Body length (from the tip of the vertex to the end of the abdomen): 23.413. Antenna length: 5.799, compound eye length: 1.314, width: 0.821; interocular distance 0.843; fastigium of vertex length 0.621; width: Head length 2.307; Pronotum length: 3.107, width: 1.838; prozona length: 1.790, metazona length 1.305, mesosternal lobe length: 1.601, width 1.205; Fore leg: femur length: 3.506, width: 0.663; tibia length: 2.609, width: 0.466; tarsus length (by segments) I: 0.525, II: 0.350, III: 1.079; claw length: 0.580. Mid leg: femur length: 4.643, width: 0.797, tibia length: 3.978, width: 0.359; tarsus length: I: 0.565, II: 0.337, III: 0.994; claw length 0.563. Hind leg: femur length: 12.984, width: 3.663, tibia length: 11.732, width: 0.404, tarsus length: I: 1.433, II: 0.655, III: 1.100. Wings: tegmina length: 19.256, wings length 2.796; Abdomen length: 6.920; width: 1.432. cerci length 0.663, width 0.384. Dorsal ovipositor valve length: 2.920; ventral Ovipositor valve length: 1.800.

VARIABILITY. The paratypes have no substantial morphological differences with the holotype described. Lenght of body 23 mm

ETYMOLOGY. This species is named after the collection locality.

Keshava jugadensis n. sp. (Figs. 18–24)

EXAMINED MATERIAL. Holotype female, Chhattisgarh, Gariyaband, Jugad, 29.VI.2014, 20° 08'42.9"N, 82°16'34.3"E altitude 438 m, coll. S.K. Gupta and collaborators, Reg.no. 18856/H5.

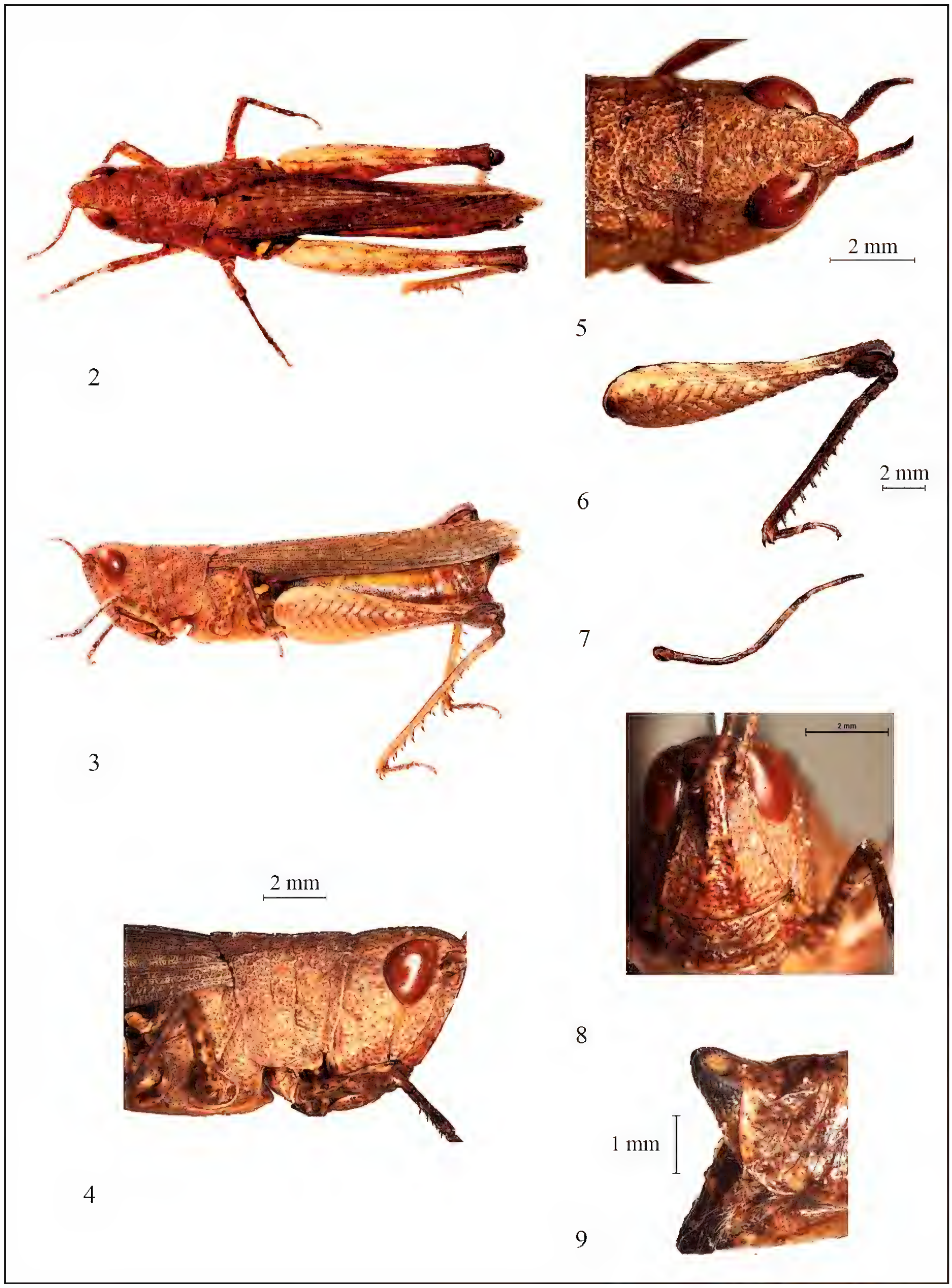
Paratype: 5 females, same data as holotype, 18857/H5-18861/H5.

DESCRIPTION OF THE HOLOTYPE. Female. Body medium sized, cylindrical; head small, eyes ovoid in shape; maximum diameter of eye slightly longer than the interocular distance; frons oblique; fastigium of vertex angulate, concave, lateral carinae elevated; median carina indistinct. Pronotum 1.6 times as long as wide, disc with two transverse sulci interrupted with median carina, with weak lateral carinae, straight only metazona and prozona lateral carinae obliterated; metazona with dark blackish stripe; surface of pronotum usually punctuate, anterior margin of pronotum straight and posterior margin rounded; posterior margin of metazona rounded. Prosternal process absent. Mesosternal lobe 1.8 times shorter than its width. Mesosternal interspace open. Wings: tegmina and hind wing well developed, slightly surpassing tip of hind knee; hind wings slightly shorter than tegmina. Abdomen 3.3 times longer than its width; cerci cylindrical, 1.8 times longer than wide, tip rounded, shorter than epiproct. Ovipositor: valvula short, end slightly hook shaped, lower valvula shorter than upper one. Ovipositor dorsal valve stout rather ventral valve short. Legs: hind femora slender 3.8 times longer than wide; slightly shorter than abdomen; upper and lower carina smooth, upper apical lobe longer than lower, inner margin of inner side without a row of stridulatory pegs; hind tibiae with outer 9 and inner 11 small spines at dorsal margin. Colour: body light brown. Pronotum disc with a dark blackish brown stripe.

Measurements (all in millimetres). Body length (from the tip of the vertex to the end of the abdomen): 25.957. Compound eye length: 1.994, width: 1.225; interocular distance 1.354; fastigium of vertex length 1.077; Pronotum length: 4.583, width: 2.728; prozona length: 2.681, metazona length 1.902, mesosternal lobe length: 0.915, width 1.714; Fore leg: femur length: 2.962, width: 0.537; tibia length: 3.345, width: 0.359; tarsus length (by segments) I: 0.680, II: 0.237, III: 1.045; claw length: 0.325. Mid leg: femur length: 3.756, width: 0.819, tibia length: 4.080, width: 0.377; tarsus length: I: 0.768, II: 0.192, III: 0.938; claw length 0.407. Hind leg: femur length: 12.380, width: 3.228, tibia length: 10.331, width: 0.382, tarsus length: I: 1.296, II: 0.684, III: 1.212. Wings: tegmina length: 18.532. Abdomen length: 12.746; width: 3.206. Cerci length 0.743, width 0.412. Dorsal ovipositor valve length: 3.910; ventral Ovipositor valve length: 2.532.

VARIABILITY. The paratypes have no substantial morphological differences with the holotype described. Length of body 26. mm

ETYMOLOGY. This species is named after the collection locality.



Figures 2–9. *Keshava shishodensis* n. sp. female. Fig. 2: dorsal view; Fig. 3: lateral view; Fig. 4: pronotum lateral view; Fig. 5: fastigium of vertex; Fig. 6: hind femur; Fig. 7: antenna; Fig. 8: frontal ridge; Fig. 9: ovipositor.

10

13

11

14

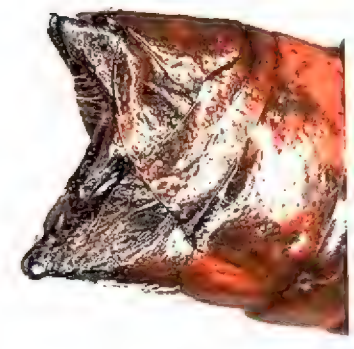
2 mm

15

16

2 mm

12



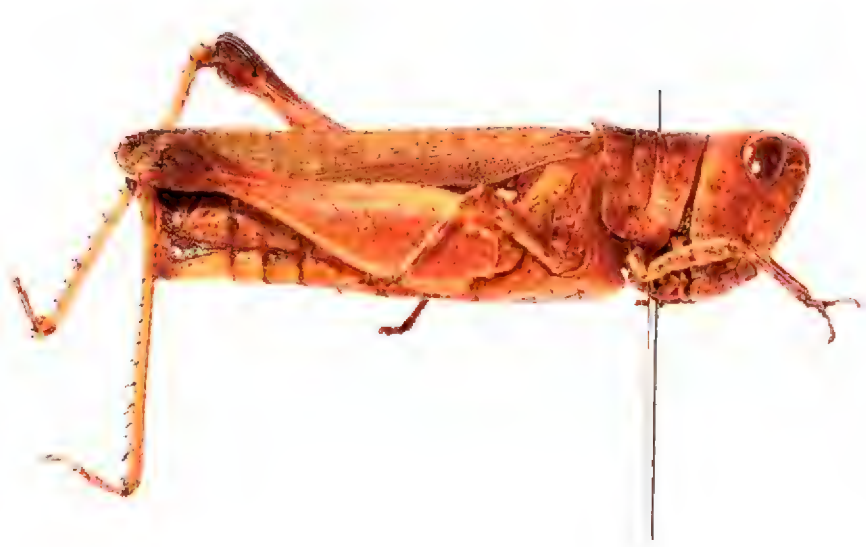
17

2 mm

Figures 10–17. *Keshava barnawaparensis* n. sp., female. Fig. 10: dorsal view; Fig. 11: lateral view; Fig. 12: pronotum lateral view; Fig. 13: fastigium of vertex; Fig. 14: hind femur; Fig. 15: antenna; Fig. 16: frontal ridge; Fig. 17: ovipositor.

18

21



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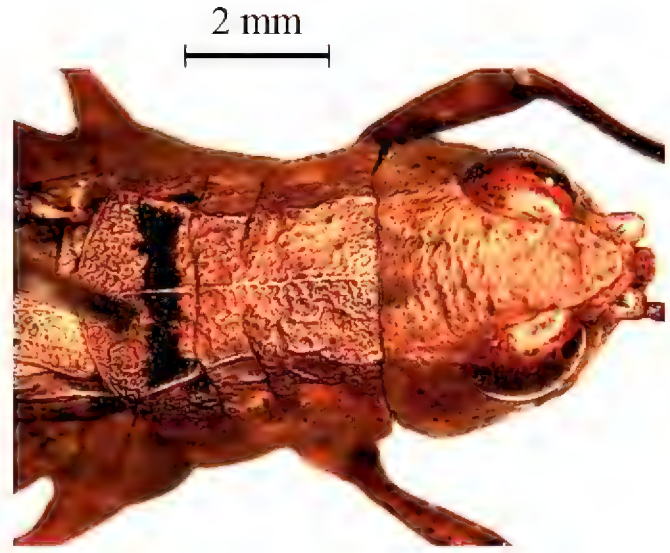

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24

Figures 18–24. *Keshava jugadensis* n. sp., female. Fig. 18: dorsal view; Fig. 19: lateral view; Fig. 20: pronotum dorsum view and fastigium of vertex; Fig. 21: pronotum lateral view; Fig. 22: frontal ridge; Fig. 23: med leg and hind leg; Fig. 24: antenna.

Keys to the genus

1. Pronotum disc with distinct lateral and median carina.....2

- Pronotum disc without distinct lateral and median carin.....*Keshava shishodensis* n. sp.

2. Pronotum lateral side below lateral carinae both side with a large black stripe, metazona without colour pattern, median carina in metazona not elevate.....*Keshava barnawaparensis* n. sp.

- Pronotum lateral side below lateral carinae both side without large black stripe, metazona with dark blackish brown colour pattern, median carina in metazona elevated.....*Keshava jugadensis* n. sp.

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Biodiversity Journal, 2017, 8 (3): 827–832

Morphological observations on a gynandromorph of *Anacridium aegyptium* (Linnaeus, 1764) (Orthoptera Acridiidae)

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ABSTRACT This paper describes and illustrates a gynandromorph of *Anacridium aegyptium* (Linnaeus, 1764) (Orthoptera Acridiidae). Its morphological features are compared with normal male and female features in this species. Biometric data are also provided. This is the first case of gynandromorphism reported in *A. aegyptium*. The specimen was collected in the field near Imperia (northern Italy).

KEY WORDS Biometry; Caelifera; Catantopinae; gynandromorphism; Italy.

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INTRODUCTION

Gynandromorphism is a teratologic condition consisting in the simultaneous presence of both male and female phenotypic characters, with a clear demarcation between the one and the other, in the same individual of an animal species with separate sexes. To whatever degree, it is always a rather uncommon phenomenon. In the class of insects, gynandromorphism is fairly widespread and has been observed in both heterometabolous and holometabolous orders (Massa, 2010). The different frequency at which it has been reported for different taxa also derives from the presence (or lack thereof) of more or less marked sexual dimorphism, as occurs e. g. in some Coleoptera and Lepidoptera.

Among Orthoptera, gynandromorphs are observed more frequently in Ensifera, which exhibit more evident dimorphism principally due to the long ovipositor typical of the females in most families of this suborder. For Caelifera, reports are much less numerous (Nickle, 1983).

This article describes and illustrates in detail a gynandromorph of *Anacridium aegyptium* (Linnaeus, 1764) (Caelifera Acridiidae Catantopinae) (Fig. 1). Previously, the specimen had only been the subject of a very short analysis (Nicoli Aldini, 1996). *Anacridium aegyptium* is a common species with wide south-western Palearctic distribution (Harz, 1975). It is widespread in the Eurasia and Mediterranean region and frequent in all Italian regions (Massa et al., 2012). It winters in adult state. Sexual dimorphism is very slightly pronounced in this species. Almost exclusively, it has to do with size (dimegethism) - with females being larger than males - and a few other morphological features, such as the shape and development of the arolium in the pretarsi. As is observed in other *Anacridium* Uvarov, 1923, pretarsi are sexually dimorphic in *A. aegyptium*. Male arolium is rather narrow and 1.5 times as long as each pretarsal claw. Female arolium is a little wider than in male, but is as long as the claws, or exceeds them only slightly in length. Stridulatory structures are not present in this species; a clicking noise is produced with the mandibles (Harz, 1975).

MATERIAL AND METHODS

The gynandromorph was collected in the field near Imperia (Liguria, northern Italy) on February 18, 1993. Since it was already dead (though still relatively fresh) by the time it reached laboratory observation, ethological data are not available, nor was it dissected. Photographs of the abdominal details were taken at a time the gynandromorph was already dead, but still fresh. Biometric measurements - antennal length, body length (from the front to the posterior end of the abdomen), length of pronotum (dorsally along the midline), tegmina, and metathoracic femora, tibiae and tarsi (Table 1) - were made at a later time, on the dry specimen, using a manual gauge and under a stereomicroscope. The specimen is stored, dry, in the author's collection.

In order to obtain comparative biometric data, measurements were also made, with the same method, on 20 males and 20 females of the same species, collected in Italy (all coming from north-western and central provinces and regions: Liguria, Piedmont, Lombardy, Emilia Romagna, Tuscany), kept dry in the entomological collections of the Department of Sustainable Crop Production - DI.PRO.VE.S., Università Cattolica, Piacenza (Table 2). In order to facilitate the measurements by giving some temporary flexibility to the insects' joints, each specimen spent a short time in a moist chamber.

ABBREVIATIONS. See figures 6–15. T = tergite; Ep = epiproct; RPp = right paraproct; LPp = left paraproct; RC = right cercus; LC = left cercus; RDV = right dorsal valve; LDV = left dorsal valve; RVV = right ventral valve; LVV = left ventral valve; LBvS = lateral basivalvular sclerite; MSgP = male subgenital plate; FSgP = female subgenital plate; S = sternite; lh = left half; rh = right half.

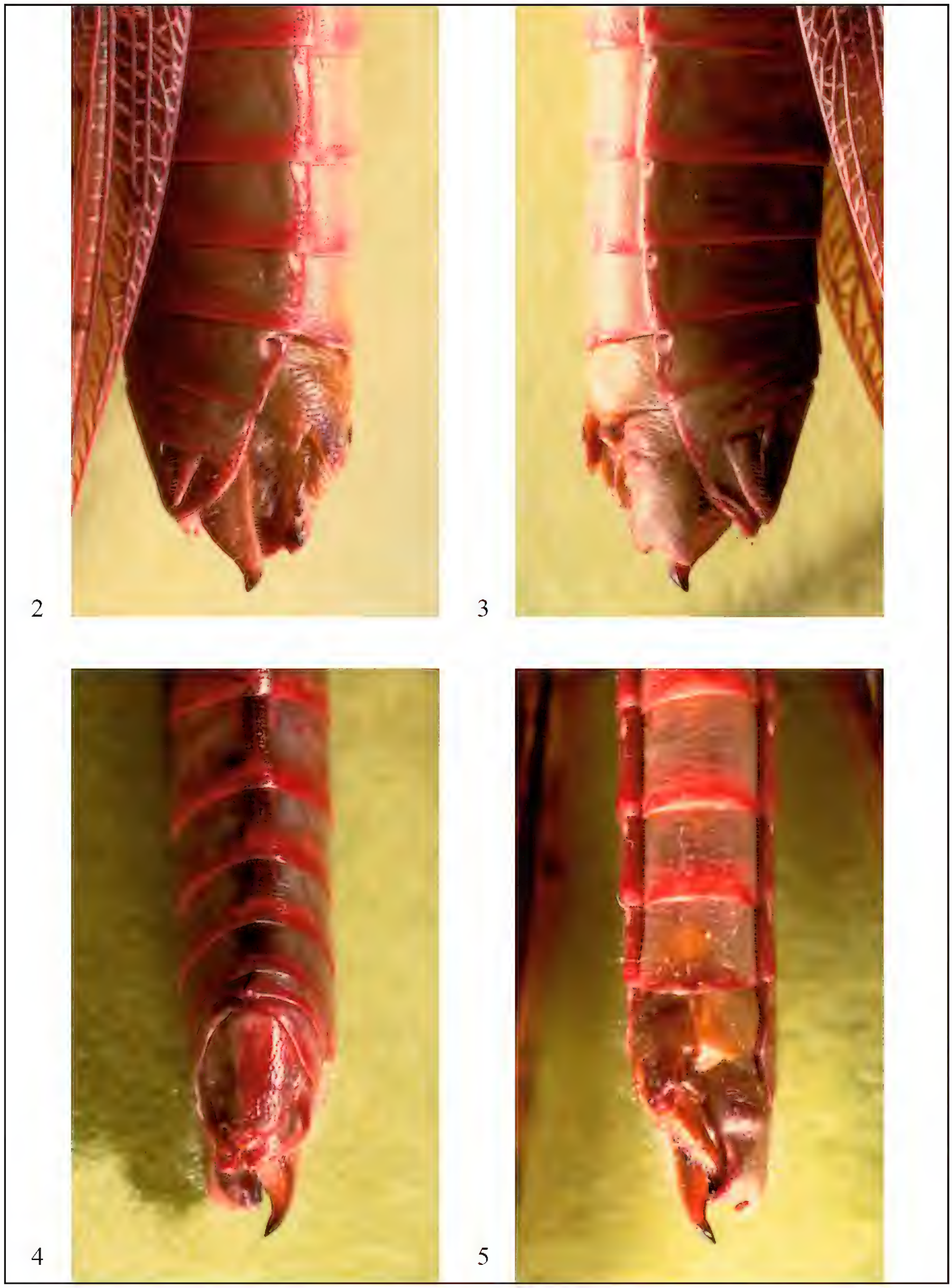
Figure 1. Gynandromorph of *Anacridium aegyptium*: dorsal view of the whole specimen (photo S. Gabbiani).

RESULTS

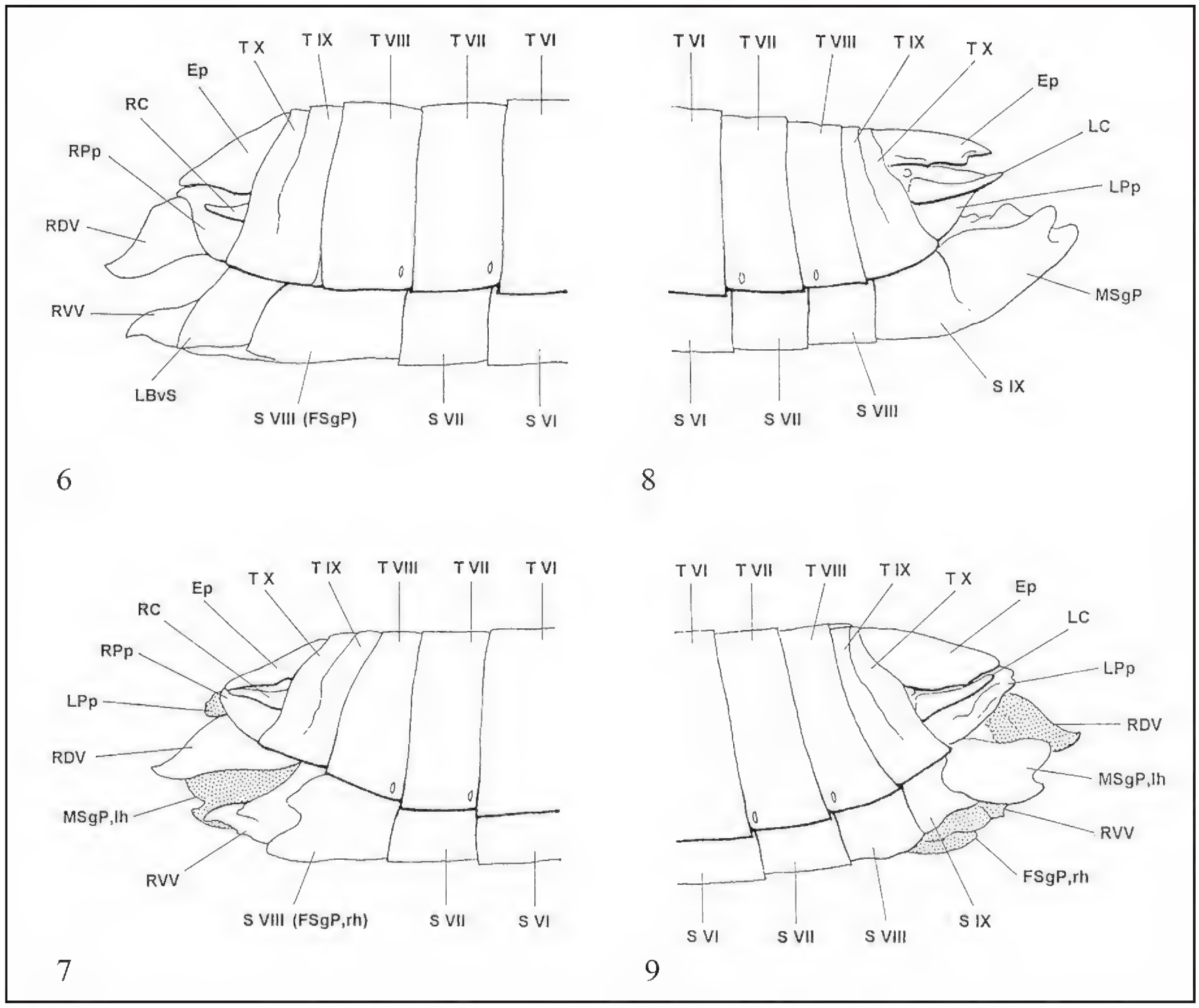
The size of the gynandromorph (body length approx. 48–49 mm, tegmina approx. 49.5 mm, no significant difference between the right and left tegmen) (Table 1) is intermediate, considering the mean male and female dimensions for this species. Harz (1975) reports that the mean length of the tegmen in male *A. aegyptium* is 46.5 mm, and 57 mm in female (also see biometric data in Table 2). The head features a very slight difference in length

Length (mm)	Right side of the body	Left side of the body
Total body	49.04	48.23
Antenna	15.91	15.06
Pronotum (midline)	11.80	11.80
Tegmen	49.57	49.46
Metafemur	26.04	24.85
Metatibia	24.12	21.70
Metatarsus	8.08	7.99

Table 1. Gynandromorph of *Anacridium aegyptium*, all biometric data measured (in mm).



Figures 2–5. Gynandromorph of *Anacridium aegyptium*. Figure 2. Right lateral view of the last segments of the abdomen. Figure 3. Left lateral view of the last segments of the abdomen. Figure 4. Dorsal view of the last segments of the abdomen. Figure 5. Ventral view of the last segments of the abdomen (photos I. Rossi).

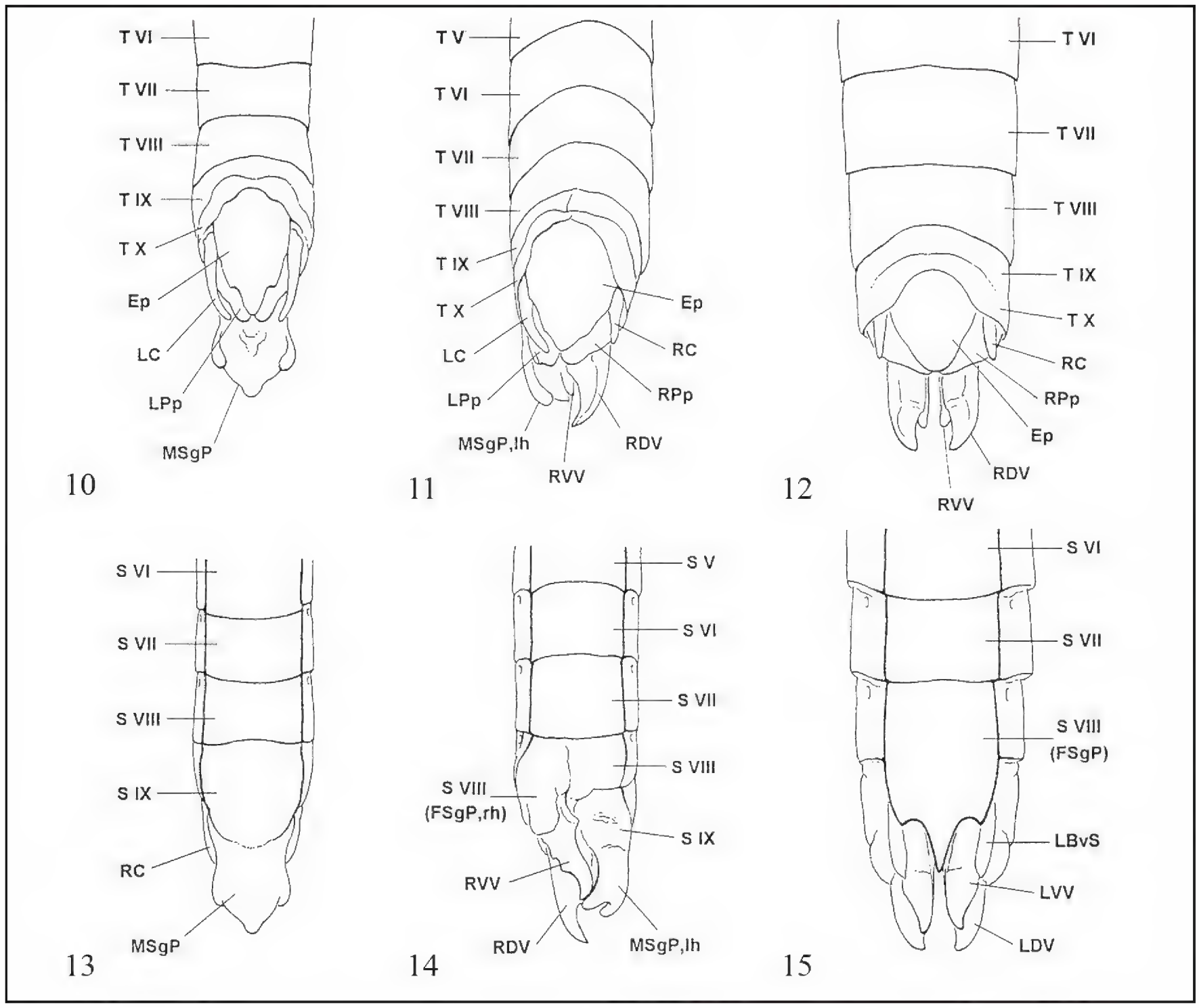


Figures 6–7. *Anacridium aegyptium*, lateral view of the last segments of the abdomen. Fig. 6: normal female, right side. Fig. 7: gynandromorph, right side. Fig. 8; normal male, left side. Fig. 9: Gynandromorph, left side. Abbreviations: see Material and Methods.

between the antennae: the right antenna is 0.85 mm longer than the left. In the thorax, pro- and mesothoracic legs on both sides are symmetric, while metathoracic legs are clearly asymmetric, the right leg being distinctly longer than the left, due to greater development in length of the femur and, especially, the tibia (Fig. 1; Table 1). Moreover, the maximum width of the right metafemur is approx. 0.2 mm greater than the left. The right metatibia is also slightly thicker than the left. With regard to the arolia, no clear difference was observed between the right and the left side of the body, in each pair of legs. All arolia in the gynandromorph seem to be similar to the male type on both sides.

Gynandromorphic features are very evident in the abdomen, where the exterior of genital and post-genital segments features the typical side bipartition of primary sexual characteristics: female on the right side and male on the left. This is evident in viii sternite, which forms an abnormal right half of the female subgenital plate, in the ix tergite, x tergite, epiproct, paraprocts, and cerci. The left half of the ix sternite is prolonged in an abnormal left half of the male subgenital plate. On the right side, we can observe the two valves of the ovipositor. The dorsal valve is normal in conformation, while the ventral valve is slightly abnormal and deviated medially (Figs. 2–5, 7, 9, 11, 14).

For comparison, the external morphology of the abdomen's rear end in a normal male and female specimen of *A. aegyptium* (Figs. 6, 8, 10, 12, 13, 15) is illustrated.



Figures 10–15. *Anacridium aegyptium*, dorsal and ventral view, respectively, of the last segments of the abdomen. Figs. 10, 13: normal male. Figs. 11, 14: gynandromorph. Figs. 12, 15: normal female. Abbreviations: see Material and Methods.

Biometric data of the ginandromorph can be compared with original data of the normal male and female specimens of the same species, taken on Italian specimens (Table 2).

DISCUSSION

As in most cases observed for gynandromorph Orthoptera (Nickle, 1983), even in this gynandromorph the external female features of the abdomen are on the right-hand side of the body (which also shows a greater development of the metathoracic leg), while the male features are on the left-hand side. Significant asymmetries of other external somatic structures are not present. The conformation of the last abdominal segments is similar to the gynandromorph of *Schistocerca gregaria* (Forskål, 1775) (albino strain) described by Pener (1964). The specimen of *A. aegyptium* illustrated above can be considered a bilateral gynandromorph, in the current sense of the term.

For the genus *Anacridium*, the only gynandromorph previously reported is a specimen of *A. moestum* (Serville, 1838) from a laboratory colony, which exhibits dorsoventral gynandromorphism (Potter, 1940). This is the first gynandromorph recorded for *A. aegyptium*. Notably, the specimen is field-collected.

According to the review by Nickle (1983) (which completed and updated previous reviews by Chopard (1938), Baccetti (1954) and Uvarov (1966) literature

Sex	Total length			Length of antenna			Dorsal length of pronotum			Length of tegmen			Length of metafemur		
	Mean ± st.dev.	Min	Max	Mean ± st.dev.	Min	Max	Mean ± st.dev.	Min	Max	Mean ± st.dev.	Min	Max	Mean ± st.dev.	Min	Max
Males (n = 20)	44.92 ± 2.31	39.36	48.43	14.44 ± 0.64	12.96	15.28	10.09 ± 0.62	8.78	10.98	47.78 ± 2.09	43.72	51.24	21.70 ± 1.10	19.30	23.86
Females (n = 20)	56.86 ± 4.55	47.70	67.80	16.82 ± 1.03	14.92	18.70	13.06 ± 0.99	10.51	14.40	60.08 ± 3.61	52.44	66.58	28.19 ± 1.82	24.03	31.76
Gynandromorph, right side (F)	49.04	-	-	15.91	-	-	11.80	-	-	49.57	-	-	26.04	-	-
Gynandromorph, left side (M)	48.23	-	-	15.06	-	-		-	-	49.46	-	-	24.85	-	-

Table 2. *Anacridium aegyptium*, biometric data (measured in mm) of normal males and females, compared with data of the gynandromorph (Min = minimum; Max = maximum; st.dev. = standard deviation).

has reported only just over 500 gynandromorphs among Orthoptera, mostly deriving from laboratory stocks or experiments. Fewer than 10% are clearly referable to bilateral gynandromorphism, which is the most extreme form of this phenomenon. Most reports describe ensiferan Orthoptera. As for Caelifera, in which, as mentioned above, this anomaly is morphologically less marked and more easily escapes observation, the instances recorded amount to a few dozen and refer, according to Nickle (1983), to 25 species. The reports are generally solely devoted to the external morphology of the anomalous specimens. The genetical, embryological, anatomical, physiological, developmental and ethological aspects of this phenomenon, which has implication for many realms in general entomology, often remain largely outside the possibility of study.

As far as the determinism of this interesting anomaly is concerned, besides Nickle (1983), see also Laugé (1985), and Massa (2010).

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Patterns of family-species distribution for organisms in Alabama, USA

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ABSTRACT Biodiversity provides multiple functions to human society. Understanding the emergent properties of biodiversity in one region is important for better conservation and strategy developing. In this study, organisms of different groups (fishes, amphibians and reptiles, mammals, butterflies and plants) in Alabama were studied by methods of family-species number distribution and entropy. The results indicate that the family-species distribution of each organism group in Alabama follows a power law, but the power exponent varies among groups. There is no significant difference for the power exponents among the groups of fishes, mammals and plants, also between amphibians and reptiles and birds. The power exponent of butterflies is quite different with others. For global birds, the power exponent is significantly different with the birds group and others in Alabama. The entropy of family-species distribution is only about half of maximum entropy within each group or overall. The implications for biodiversity conservation and strategy making are discussed. Characterizing the family-species distribution at different scales will provide a quantitative approach for comparing and evaluating hierarchical properties of biodiversity.

KEY WORDS Biodiversity; emergent property; entropy; evolution; power laws.

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INTRODUCTION

Human societies are connected to and dependent on the biodiversity and its functions through the flow of materials and energy (e.g., Costanza et al., 1997; Daily, 1997). The last several decades have been marked by important discoveries and scientific advances in our understanding of biodiversity. One of the fundamental questions in ecology is why there are various species coexisting in nature (e.g., Hutchinson, 1959; May, 1972). Understanding the macroscopic patterns of species diversity may provide better strategies for biodiversity conservation at a large scale from a holistic perspective. When biodiversity is referred in the context of species abundance and above, there is a general pattern emerged: a few taxonomic groups have more species number but most have limited species number. Yule (1925) studied taxonomic abundance distribution in genera and proposed a continuous branching process model to explain the distributions at the generic level and found that they were power laws in the limit of equilibrated populations. This frequency distribution of species within taxonomic groups has the shape known as "hollow curve" (Willis & Yule, 1922). Burlando (1990; 1993) tested the fractal geometry hypothesis through the examination of size-frequency distributions of taxa with different numbers of subtaxa. Late more and more studies

indicated the geometric nature in biota and its possible relationship with speciation and extinction in evolutionary processes (e.g., Chu & Adami 1999; Scotland & Sanderson 2004; Maruvka et al., 2013). This leads to the important hypotheses that fractal nature or power laws can describe the scaling relationships in the emergent patterns of biodiversity at different scales although the underlying processes may be complicated (e.g., Brown et al. 2002; Marquet et al., 2007; Lorimer et al., 2015). Furthermore, all the species of different families in this region are formed as a self-organized network, such as regional biota. The species network should follow the principle of maximum entropy (MaxEnt),which means the probability distribution of species best represents the current state and reaches the largest entropy(e.g., Jaynes, 1957). MaxEnt has been frequently used in ecology (Harte, 2011). It can be assumed that species within families follow MaxEnt during their evolution and development. But more case studies from the different parts of world are needed to show the validity of scaling relationships and possible implications.

The state of Alabama is located in the southern region of USA, which is well known for its high biodiversity due to its warm climate and natural geography (Mount, 1975). The terrestrial habitats span from the gulf beaches to the lower Appalachian Mountains. The state also contains a wealth of water and wetland resources. The Mobile-Tensaw Delta is recognized as one of the most significant and important delta complexes in the nation. The great physical diversity provides habitat for abundant wildlife and plant species. Alabama is consistently ranked among the top three to five states in terms of overall biodiversity based on the report from Alabama Department of Conservation and Natural Resources (www.outdooralabama.com). However, due to increasing human population, urbanization and agricultural development (Chen, 2010), the biodiversity conservation in Alabama is under challenge. Huge effort was spent to document species in Alabama (e.g., Mount, 1975; Mettee et al., 1996; Mirarchi, 2004). It is necessary to study overall species at state level as a whole because some properties of complexity can only emerge at a large scale (Noss & Harris, 1986; Green et al., 2006; Chen, 2008). The goal of this study is to find the patterns of family-species number distribution for organisms in Alabama. The specific objectives include (i) whether the patterns of family-species number distribution follow power laws; (ii) whether similar power laws exist in family-species number distribution for different organism groups (e.g., fishes, birds, mammals and plants); (iii) whether species from different families follow or close to MaxEnt within each group or overall; and (iv) whether there are possible implications for biodiversity conservation.

MATERIAL AND METHODS

Study area

Alabama is located in the southern region of USA, which is between the southern foothills of the Appalachian Mountain Range and the Gulf of Mexico (between 31° and 35°N). Alabama has a warm, humid, subtropical climate. Summers are hot and humid with an average high temperature around 33°C. The driest times of the year are usually in late summer and fall. Winters are cold and wet. Regional annual precipitation varies from 150 to 162 cm in the north part and 180 to 195 cm along the coast (Carter & Carter, 1984). Forests cover roughly two-thirds of the state and reach about 8.9 million hectares (Chen, 2010). Alabama is ranked as the third largest commercial forest industry in the nation after Oregon and Georgia. But Alabama's forests are far more diverse than those of Oregon and Georgia with a comparable abundance of forested acreage (Phillips, 2006). Tree species in Alabama was documented to vary from 145 to 193 while compared to an estimated 16 to 60 species occurring in Oregon (Ricketts et al., 1999). Due to the combination of mild and humid climate, remarkable surface drainage and diverse physiographic subdivisions, the species of Alabama have reached a high level diversity (Mount, 1975; Mettee et al., 1996). It is therefore an important consideration for research and conservation in the USA.

Dataset

The dataset includes the information of species in each family for fishes, amphibians and reptiles, birds, mammals, butterflies and plants. The detailed information is listed in Table 1.

The data of global birds were also used for comparison.

Data sorting and statistics

For each organism group, the family numbers and species number within each family were counted and recorded. Then, family numbers (p_i) with species number $x_i < 5, 10, 15,..., N$ were counted respectively. N is the maximum number of species in a family. After then, the accumulated percentage (y_i) of family number in total families was calculated as:

$$y_i = \frac{p_i}{p_{N+1}} \times 100$$

where p_i is the family number with species number less than i, and p_{N+1} is the family number with species number less than $N+1$, which is also the total family number.

	Family number	Species number	Data sources	Power laws	R^2 and p
Fishes	40	336	Mettee et al., 1996	$y=0.0873x+1.8337$	$R^2=0.8313$ $p<0.05$
Amphibians and reptiles	28	183	Mount, 1975	$y=0.1451x+1.7546$	$R^2=0.9262$ $p<0.05$
Mammals	24	77	Mirarchi, 2004	$y=0.0985x+1.8673$	$R^2=0.9683$ $p<0.05$
Birds	60	324	Mirarchi, 2004	$y=0.156x+1.759$	$R^2=0.9329$ $p<0.05$
Butterflies	6	139	Howell & Charny, 2010	$y=0.6485x+0.8542$	$R^2=0.9513$ $p<0.05$
Plants	240	4273	Alabama Herbarium Consortium (http://floraofalabama.org)	$y=0.0803x+1.8017$	$R^2=0.6036$ $p<0.05$
Global birds	145	9698	Monroe & Sibly, 1993	$y=0.1931x+1.5005$	$R^2=0.8336$ $p<0.05$

Table 1. Information of organism groups in Alabama and global birds.

Group	Entropy within group	Maximum Entropy within group	Entropy of all species	Maximum Entropy for all species
Fishes	1.107	2.526	2.023	3.727
Amphibians and reptiles	1.116	2.311		
Mammals	1.178	1.887		
Birds	1.471	2.511		
Butterflies	0.615	2.143		
Plants	1.806	3.632		
Global birds	1.682	3.987		

Table 2. Entropy and maximum entropy of families and species in Alabama.

A commonly used least squares technique was used for correlation analysis between $\log_{10}(x_i)$ and $\log_{10}(y_i)$ through linear fitting ($y=ax+b$) by SAS software (SAS Institute Inc., NC, USA). Slope (a) is also called the exponent of power laws or power exponent. The slope a values of different organism groups were compared by T-test (Sokal & Rohlf, 1995). All the tests were considered statistically significant as $p < 0.05$.

Entropy was calculated as the following, which is similar to Shannon entropy

$$Entropy = -\sum_{i=1}^{m} p_i \log_{10}(p_i)$$

m is the number of families,

$$p_i = \frac{s_i}{\sum s_i}$$

s_i is the species number within family i,

$$MaxEnt = -\sum (1/S) \log_{10}(1/S)$$

S is the total species number within a group or overall.

RESULTS AND DISCUSSION

The family-species distribution for each group of organisms in Alabama does follow a power law (Table 1), but the power exponent varies among groups. There is no significant difference for the power exponents among the groups of fishes (0.0873), mammals (0.0985) and plants (0.0803), also between amphibians and reptiles (0.1451) and birds (0.156). The power exponent of butterflies (0.6485) is quite different with others. The power exponent is 0.143 for all combined species and families in Alabama. For global birds, the power exponent is 0.1931, which is significantly different with any (or all) organism group in Alabama.

The entropy within group and overall does not reach or even close to maximum entropy (Table 2). It is only about half of MaxEnt for each group including global birds. They are far away to be evenly distributed or from equilibrium.

The results here confirm the work of Yule (1924) and Burlando (1990) that family-species distribution tends to follow power laws but often show strong deviations from such laws. Yule (1925) considered that the deviations from the power laws were attributed to the fact that the populations had not reached equilibrium. Chu & Adami (1999) indicated that the deviations were time independent and reflected specific environmental conditions and pressures to which the communities under consideration was subjected during evolution; they suggested that power law distributions are statistically inevitable for taxa higher than species. This means that some families under certain environment might produce more species, while others might have limited species. This is known as preferential attachment, which leads to complex networks that have properties different from classical random network theory (Lorimer et al., 2015). Our results do not support Singh et al. (2007) found that the evolutionary process is characterized by a power law with a universal exponent that is independent of the pair of species compared. Disturbances and land use change may dramatically change species and family distribution and cause the deviations in the power laws. The power exponent was considered to be near 1 (Burlando, 1990; 1993). However, in this study the power exponents are much lower than 1. These low values of the exponents may be related to a very low rate of beneficial taxon-forming (or niche-filling) mutations and also self-organized criticality (Chu & Adami, 1999). Spitzer (1964) indicated that the underlying stochastic process responsible for the observed behavior can be explained by a random walk. Same as the entropy measure, which is far less than the MaxEnt within each group or overall. This means that family-species distribution is far away to even distribution or equilibrium.

The similar power exponents in mammals, plants and fishes may indicate that mutualistic interactions in the dynamics of terrestrial and fresh water ecosystems. These multispecies networks (e.g., plant-mammal, plant-fish) and their functional consequences (e.g., food web or similar spatial scales) may constitute for strong coevolution (Thompson, 2005). Similar interactions may also exist for amphibians and reptiles, and birds. The quite different power exponent in butterflies or birds may indicate their relationships possibly exist

with only some special plants or landscape (Chen & Feng, 2016). The different power exponents for birds in Alabama and world may indicate that it will be wrong to extrapolate the family-species relationship from a regional scale to global scale.

Studying the macroscopic patterns of family-species distribution in Alabama not only gives theoretical insight into the regional biota, but also provides implications to devise long-term estimations and strategies for biodiversity monitoring and conservation. First, we can use the relationships of family-species distribution in Alabama to identify conservation priority, such as identifying some families with only one or two species and the spatial distribution (Chen, 2008). Second, it is an evolutionary process that some species may become extict or some new species may come out because they are far away from equilibrium. With the local land use change, the evolutionary process may be altered. Third, we need to pay attention to monitoring the emergent properties (e.g., strength of self-organization) of biodiversity under land use change, rather than just single species, such as comparing the hierarchical relationships between family-species distribution by using historical (fossil record) information. It may provide suggestions whether the continuing development in land use change at the state level will affect this hierarchical relationship in biota. Furthermore, it can be used to estimate species number at a large area based on the appeared family number, which may be used as background information. Finally, it may provide a method to study the contribution of major landscape (ecosystems) with more species or family number in biodiversity conservation (e.g., Chen et al., 2005). These areas may be important for biota evolution, especially for research in speciation, extinction and coevolution.

CONCLUSIONS

Characterizing the family-species distribution in Alabama may be helpful to study biodiversity and evolution at mesoscale. This study will provide a quantitative approach for comparing and evaluating hierarchical biodiversity at a large area. If further studies can be conducted at different spatial and temporal scales, they will help to determine the areas with high speciation and coevolution, where should avoid for land use change or major industrial development in order to maintain high integrity of biodiversity. The cost to monitoring all species at a large area could be decreased with the development of citizen sciences program and monitoring technology (e.g., camera traps and drones).

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Description of *Alvania oetyliaca* n. sp. from the Mediterranean Sea (Mollusca Gastropoda Rissoidae)

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ABSTRACT A new Mediterranean species of the genus *Alvania* Risso, 1826 (Rissooidea Rissoidae) is described: *Alvania oetyliaca* n. sp. All known specimens come from the type locality: Itilo Bay, Peloponnese, Greece. It is compared with the most similar congeners from the Mediterranean Sea: *A. subcrenulata* (Bucquoy, Dautzenberg et Dollfus, 1884), *A. amatii* Oliverio, 1986, *A. nestaresi* Oliverio et Amati, 1990, *A. balearica* Oliver et Templado, 2009, *A. aliceae* Amati, 2014, *A. hirta* Monterosato, 1884 and *A. cancellata* (Da Costa, 1778). It is also compared with *Alvania sleursi* (Amati, 1987) from the Atlantic and *A. laurae* Brunetti et Vecchi, 2012 from the Pleistocene of Italy.

KEY WORDS Gastropoda; Rissoidae; Mediterranean Sea; *Alvania*; nova species; taxonomy.

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INTRODUCTION

The Mediterranean species of the genus *Alvania* Risso, 1826 (Rissoidae) have shells small for the family, ranging from to 1 mm length of *A. maximilicutiani* Scuderi, 2014 (Scuderi, 2014) to 7 mm length of *A. mamillata* Risso, 1826 (Amati et al., 2017). Their shells are fragile to robust, generally conical-ovate, and with weak to robust clathrate sculpture. They live in a wide variety of environments, from intertidal to deeper algal facies (e.g. Tringali, 2001; Amati, 2012), but also in the aphotic realm, from -1340 m (Gofas, 2007) down to the abyssal depths of -4300 m (Bouchet & Warén, 1993). Geographically, the genus *Alvania* as currently conceived occurs in the north-eastern Atlantic and the Mediterranean Sea, the north-western Atlantic and the Caribbean, the eastern Pacific, the Indo-west Pacific, the temperate Australia and South Africa (Ponder, 1985). This genus is one of the most diversified groups within the family Rissoidae and is particularly species-rich in the Mediterranean Sea, with over 70 recognized species (Gofas, 2014; Gofas et Le Renard, 2016) including several species-complexes (e.g. *A. lineata* Risso, 1826, *A. scabra* (Philippi, 1844), *A. dictyophora* (Philippi, 1844) and *A. subcrenulata* (Boucquoy, Dautzenberg et Dollfus, 1884). The complex of *A. subcrenulata* has been recently described (Oliverio, 1986; Oliverio & Amati, 1990; Oliver & Templado, 2009; Gofas et al., 2011; Scaperrotta et al., 2010; 2011; 2012; Amati, 2014). A population of the *A. subcrenulata*-complex from Peloponnese, Greece (Ionian Sea) - morphologically distinct from all other known members - is here described as new, and compared with the most similar known species

from the Mediterranean Sea. The new species is also compared with the congener *A. sleursi* (Amati, 1987) from the Azores Island and with the extinct *A. laurae* Brunetti et Vecchi, 2012 from the Lower Pleistocene of Piacenza (Italy).

MATERIAL AND METHODS

The samples studied herein are stored in public and private collections, as detailed below, and all shells have been sorted out of bioclastic sediment samples.

Photographs have been taken with a Sony Cyber-Shot digital camera mounted on a Kyowa KBS stereomicroscope, edited with the Combine-Z software (Hadley, 2006). Scanning Electron Microscope (SEM) photographs were taken at the Interdepartmental Laboratory of Electron Microscopy (LIME, University "Roma Tre", Roma, Italy), by using a Philips XL30. Current systematics is based on the World Register of Marine Species (WoRMS, 2017) .

ABBREVIATIONS AND ACRONYMS. BA: Bruno Amati collection (Rome, Italy); CS: Carlo Smriglio collection (Rome, Italy); IN: Italo Nofroni collection (Rome, Italy); IRSN: Institut Royal des Sciences Naturelles de Belgique, Brussell; JT: José Templado collection (Madrid, Spain), MCZR: Museo Civico di Zoologia, Roma; MNHN: Muséum National d'Histoire Naturelle, Paris, MO: Marco Oliverio collection (Rome, Italy); SC: Stefano Chiarelli collection (Vallelaghi, Trento, Italy); SEM: scanning electron microscope; isl/s: island/s; sh: shell/s; v: varix; v.: versus.

RESULTS

Systematics

Superorder CAENOGASTROPODA Cox, 1960
Superfamily RISSOOIDEA Gray, 1847
Family RISSOIDAE Gray, 1847
Genus *Alvania* Risso, 1826

Type-species: *Alvania europea* Risso, 1826: 142, pl. IX, fig. 116 = *Alvania cimex* (Linnaeus, 1758) (*Turbo*), by subsequent designation Nevill, 1885: 105.

Alvania oetyliaca n. sp.
(Figs. 1–13; Tables 1–3)

TYPE LOCALITY. South of Itilo Bay, 36°41'19"N, 22°23'11"E, -6 m, Peloponnese (Greece), Ionian Sea (Fig. 20).

TYPE MATERIAL. Holotype (MNHN IM-2000-33612) H. 2.1 mm, W. 1.35 mm (Stefano Chiarelli legit, 18.VIII.1989) (Figs. 1–3, 10–13); 10 paratypes (5 juv.) (SC) (type locality); 2 paratypes (type locality) (BA).

OTHER EXAMINED MATERIAL. 20 sh (type locality) (SC); 2 sh juvenes (type locality) (SC); 3 sh (type locality) (BA).

Alvania amatii Oliverio, 1986. Holotype and 5 paratypes (MCZR); 20 paratypes (MO); 5 paratypes (BA); Aydincik (Turkey), IX.1990, 6 sh (BA); Bodrum, loc. Gölköy, Muğla (Turkey), -0.5 m, VIII.1992, 2 sh (SC); Fethiye, loc. Balaban, Muğla (Turkey), -44.5 m, VIII.1992, 2 sh (SC); Fethiye, loc. Aquarium, Muğla (Turkey), -27 m, VIII.1992, 63 sh (SC); Zakynthos Isl. (Greece), -2/3 m, 16 sh (BA); Cephalonia Isl., Agia Efimia (Greece), -7/8 m, VIII.1990 1 sh (BA); Rodi Isl. (Greece), 2 sh (BA); Gournia, Crete Isl. (Greece), 9 sh (BA); Crete Isl. (Greece), 3 sh (BA); District of Kirenya (Cyprus), -7 m, VIII.1992, 2 sh (SC); Capo Greco Protaras (Cyprus), IX.2011, 30 sh (BA); Sant'Janni Isl. Maratea, Potenza (Italy), -24 m, 27 sh (BA); Scilla (Italy), -43/44 m, VII.2015, 33 sh (BA); Scilla (Italy), -36 m, XII.1994, 102 sh (SC); Taormina (Italy), -32 m, XI.1998, 113 sh (SC).

Alvania nestaresi Oliverio et Amati, 1990. Holotype and 5 paratypes (MCZR), 15 paratypes (MO), 15 paratypes (BA), Almuñecar, Granada (Spain) -20 m, 5 sh (BA); La Herradura, Granada (Spain) -18/20 m, VIII.1993, 49 sh. (SC); La Herradura, Granada (Spain) -13/14 m, VIII.1994, 11 sh (SC); Getares, Punta Carnero, Cadiz (Spain), beached, 1988, 2 sh (BA); Getares, Algeciras, Cadiz (Spain), beached, VIII.1985, 2 sh (BA); Getares north Algeciras, Cadiz (Spain), beached, IX.1987, 2 sh (BA); Cabo de Palos, Murcia (Spain), 1 sh (BA); Cabo de Gata, Almeria (Spagna) -4/5 m, VIII.1994, 3 sh (SC); Cadaqués, Gerona (Spain) -25 m, 2 sh (BA).

Alvania subcrenulata. Lectotype (ex Dautzenberg collection MNHN n° 24812), 1 paralectotype, St. Raphael (France) Dautzenberg collection

(IRSN, Brussel), 13 paralectotypes, Cannes (France) (Monterosato collection ex Dautzenberg collection, MCZR, L10.22134); Salina Island, Sicily (Italy), -35 m >1000 sh (BA); Castiglioncello, Livorno (Italy), rock pools, XII.1991, 1 specimen (SC); Scilla, Reggio Calabria (Italy), -36 m, XII.1994, 6 sh (SC); Taormina, Sicily (Italy), -32 m, XI.1998, >100 sh (SC); Cannizzaro, Sicily (Italy), -45/46 m, 22 sh (SC); Porto Istana, Sardinia (Italy), beached, X.1983, >200 sh (SC); Giglio Isl., Grosseto (Italy), -30 m, X.1993, >500 sh (SC); Punta degli Infreschi, Salerno (Italy), -50 m, VII.1994, 5 sh (SC); Getares, Algeciras (Spain), rock pools, VIII.1994, 31 sh (SC); Getares, Algeciras (Spain), -2/3m, VIII.1994, 31 sh (SC).

Alvania balearica Oliver et Templado, 2009. Topotypes, 45 sh, from the Baleares (Minorca and Ibiza) and Columbretes (Spain), 10–40 m depth (JT).

Alvania aliceae Amati, 2014: holotype (MNHN IM-2000-27248), 1 paratype: (MNCN 15.05/ 60121), 1 paratype (MCZR 0228 cabinet of typical material), 5 paratypes (IN), 5 paratypes (MO), 5 paratypes (BA), 1 paratype (CS).

Alvania hirta Monterosato, 1884. Pozzallo -40 m (Italy), VIII.1986 5 sh (BA); Cannizzaro, Sicily (Italy), -30/43 m, 160 sh (BA); Cannizzaro, Sicily (Italy), -45/46 m, >800 sh (SC); Capo Asparano, Sicily (Italy), IX.1985, 67 sh (BA); Vendicari, Sicily (Italy), -28 m, 1 sh (BA); Salina Isl., Sicily (Italy), -35 m, 2002, 60 sh (BA); Marzameni, Franata di levanter, Sicily (Italy), -33 m, 14 sh (BA); Island delle Correnti (Italy), -1.5 m, 1 sh (BA); Scilla (Italy), -43/44 m, VII.2015, 29 sh (BA); Scilla (Italy), -42 m, I.1992, 19 sh (SC); Scilla (Italy), -36 m, XII.1994, 62 sh (SC); Taormina, Sicily (Italy), -32 m, XI.1998, >100 sh (SC); Torre di Vendicari, Sicily (Italy), -34 m, VIII.1987, 2 sh (SC).

Alvania cancellata (Da Costa, 1778). Madera Isl., 11 sh (Monterosato coll. ex Watson coll., MCZR L10.22125); Giglio Isl., (Italy) -27/30 m, 20 sh (BA); Castiglioncello, Livorno (Italy) rock pools, XII.1981, 6 sh (SC); Giglio Isl., (Italy) -30 m, X.1993, 13 sh (SC); Argentario, Argentarola Isl., Grosseto (Italy) -6/7 m, XI.1991, 3 sh (SC); Argentario, Cala Grande, Grosseto (Italy) -28.5 m, XI.1990, 11 sh (SC); Argentario, Grosseto (Italy) -31 m, X.1990, 52 sh (SC); S. Stefano Isl., Ventotene Isl. -40 m, 1 sh (BA); Bosa Marina, Sardinia, 3 sh (BA); Lampedusa Isl., 2 sh (BA); Cala Gonone, Dorgali, Sardinia -2/4 m, 2010, 8 sh (BA); Salina Isl. 'Grotta dei gamberetti' -35 m, 2002, 1 sh (BA); S. Pietro Isl., loc. Punta -1/4 m, IX.1996, 4 sh (BA); Capo Asparano, Sicily, IX.1985, 1 sh (BA); Vendicari Isl. (Sicily) -28 m, 6 sh (BA); Scilla -43/44 m, VII.2015, 5 sh (BA); Scilla, Reggio Calabria (Italy), -36 m, XII.1994, 9 sh (SC); Scilla, Reggio Calabria (Italy), -43.5 m, VI.1992, 8 sh (SC); Cannizzaro, Sicily (Italy), -45/46 m, 20 sh (SC); Porto Istana, Sardinia (Italy), beached, X.1983, 5 sh (SC); Umag (Croatia), beached, 43 sh (BA); Lastovo Isl. (Croatia), -50 m, 56 sh (BA); Torre Flavia, -26 m, 1986, 4 sh (BA); La Herradura, Granada (Spain), -13/14m, VIII.1994, 64 sh (SC); Zakynthos Isl. (Greece), -2/3 m, 1990, 2 sh (BA); Fethiye, località Balaban, Muğla (Turchia), -44.5 m, VIII.1992, 7 sh (SC); Fethiye, località Aquarium, Muğla (Turchia), -27 m, VIII.1992, 1 sh (SC).

Alvania sleursi. Holotype (Dautzenberg coll. IRSN), 32 paratypes (Dautzenberg coll. IRSN), 4 paratypes (ex Dautzenberg coll. MCZR), 25 paratypes (Dautzenberg coll. IRSN), 12 paratypes (ex Marie coll., ex Dautzenberg coll. IRSN); Ponta Delgada, Azores Isl., 1sh (BA).

DESCRIPTION OF THE HOLOTYPE. See Table 1 for ranges of measurements. Shell small for the genus (Figs. 1–3 and 10–13), height 2.10 mm, width 1.35 mm, solid, conical-ovate, with subsquare outline with the first whorls turricolated, height/width ratio1.55. Protoconch (Fig. 11) paucispiral, with a moderately twisted nucleus, of 1.30 whorls; height 0.33 mm; diameter of the nucleus 0.10 mm; diameter of the first half whorl 0.21 mm; maximum diameter 0.32 mm; sculptured by coarse tubercles randomly arranged. Protoconch-teleoconch boundary well marked. Teleoconch of 3.25 convex whorls, with impressed sutures. Axial and spiral sculpture of the same strength. Axial sculpture of 14 + v thin, orthocline on the first whorls and slightly prosocline ribs on the last whorl, smaller than the interspaces, reaching the base. Axials thickening in the subsutural area on the penultimate whorl and especially on the last whorl, forming small nodules. Shortly before reaching the varix, these nodules turn away from the suture, simulating a spiral cord. Two spiral cords (II and IV) starting immediately after the protoconch-teleoconch boundary. Spiral cords I and III absents. Deep and square interspa-

ces. Last whorl with 6 thin and equidistant spiral cords on the last whorl, 2 over the aperture and 4 slightly thicker on the base. Small tubercles barely acute, at the intersections. Micro sculpture on teleoconch of micro tubercles arranged in spirals (Figs. 12, 13). Umbilical chink absent. Aperture large, pear-shaped, rounded ovate anteriorly, aperture height 0.97 mm, shell height/aperture height ratio 2.16. Large external varix more than twice as broad as the axial ribs, slightly prosocline, with five weak and elongated internal teeth. Columella smooth. Coloration monochrome, white. Operculum and soft parts unknown.

VARIABILITY. See Tables 1–3 for ranges of measurements. Maximum size: 2.41 mm height and width 1.46 mm. External varix with five-six weak and elongated internal teeth. Rare specimens with light brown spiral bands in particularly fresh samples.

ETYMOLOGY. This species is named after the Latin name Oetylus (in Greek Oitylo = Οίτυλο), of the type locality in the Gulf of Kalamata (most famous as the Gulf of Messenia).

DISTRIBUTION AND BIOLOGY. So far known only from the type locality, Itilo Bay, Peloponnese, Greece, Ionian Sea (Mediterranean Sea). Empty shells were found in bioclastic sediment collected at -6 m by the second author.

REMARKS. In recent decades the checklist of the Hellenic malacofauna has been enriched with new records of species of the genus *Alvania*: *A. schwartziana* Brusina, 1866, *A. fractospira* (Oberling, 1970), *A. colossophilus* Oberling, 1970, *A. hallgassi* Amati et Oliverio, 1985, *A. amatii* Oliverio, 1986, *A. datchaensis* Amati et Oliverio, 1987, *A. settepassii* Amati et Nofroni, 1985, *A. clarae* Nofroni et Pizzini, 1991 and *A. dalmatica* Buzzurro et Prkic, 2007 (e.g. Oberling, 1970; Zenetos et al., 1997; Amati, 2012; Manousis, 2012; Romani, 2014; Romani et al., personal unpublished data).

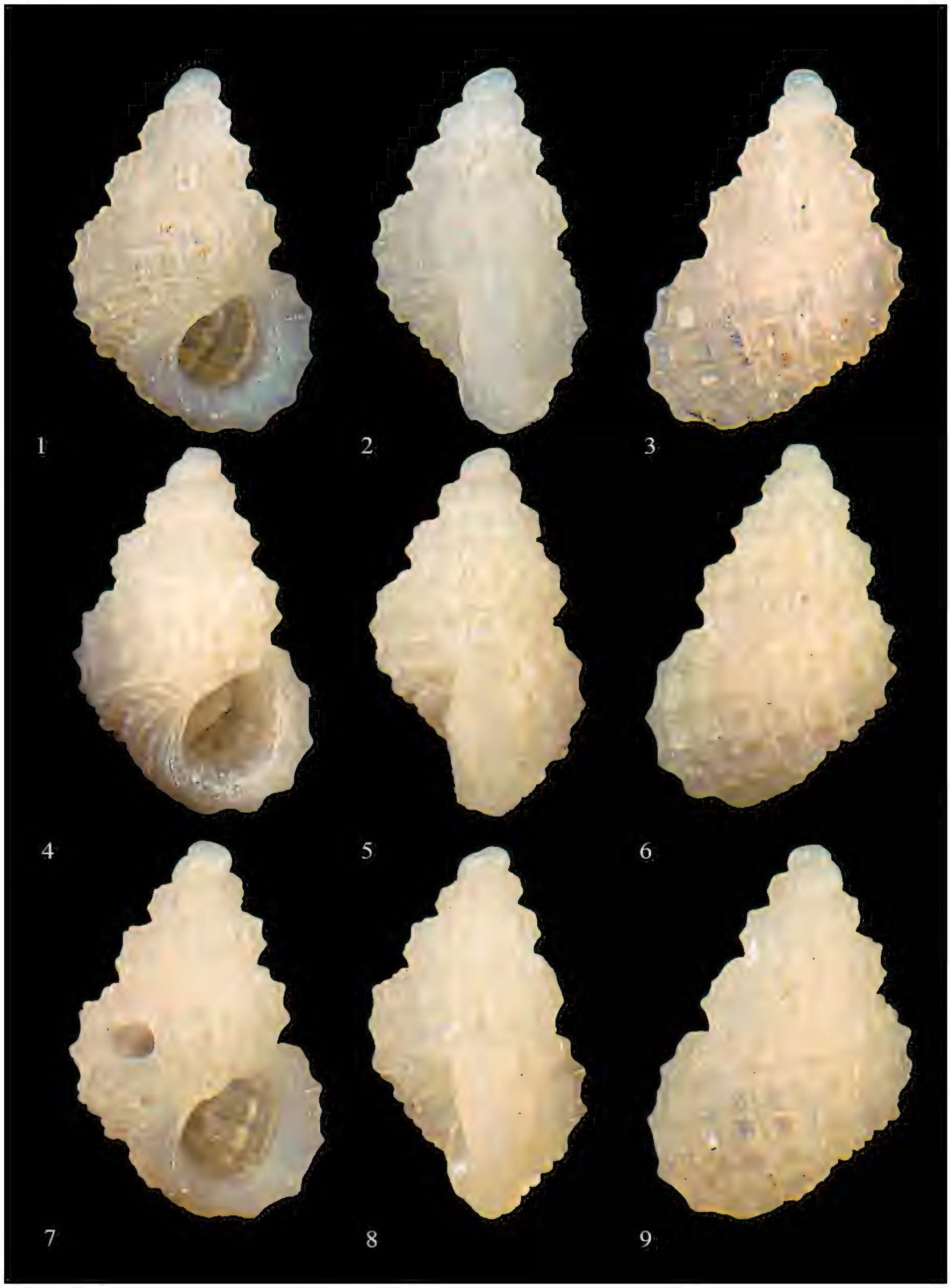
For the Greek waters, Deshayes (1835) listed under *Rissoa* Desmarest, 1814 only 4 taxa referable to 3 common species of *Alvania* (updated systematic position): *R. lactea* Michaud, 1830; *R. crenulata* Michaud, 1830 [= *A. cancellata* (da Costa, 1778)] sensu Deshayes = *A. cimex* complex; *R. cancellata* Desmarets, 1814 [= *A. cimex* complex]; *Rissoa buccinoides* Deshayes, 1835 = *A. discors* (Allan, 1818). Most recently, Zenetos & Van Aartsen (1995) listed for Rhodes Island 5 *Alvania* species. De Smit & Baba (2000) listed 6 *Alvania* species found in southern Cephalonia and Romani et al. (2017) for the Corfù Island listed 17 *Alvania* species. Koukouras (2010) listed for the Greek waters, 27 taxa of *Alvania* referable to 25 species: *A. consociella* Monterosato, 1884 = *A. lanciae* (Calcara, 1845) e *A. dorbignyi* (Audouin, 1826) = dubious record. Manousis (2012) listed for the Greek waters, 28 species of *Alvania*, two of which belonging to the *A. subcrenulata* group: *Alvania subcrenulata* and *Alvania amatii* Oliverio, 1986.

Comparisons of diagnosis. *Alvania subcrenulata* (Fig. 18, see also Oliverio & Amati, 1990: 85, tav. I, figs. 2 and 4, tav II, fig. 8; Giannuzzi-Savelli et al., 2002: 103, figs. 400, 408c; Gofas et al., 2011: 180, 2 unnumbered figs; Scaperrotta et al., 2012: 56, 5 unnumbered figs; Amati, 2014: 92, 93, figs. 3A–D, 4A–B) differs from *A. oetyliaca* n. sp. by the more slender profile and larger sizes (2.45-3.0 mm height v. height 2.1–2.41 mm); for the number of spiral cords on the last whorl (7–8 v. 6), and above the aperture (3–4 v. 2); the protoconch with tubercles and apical keel v. coarse tubercles randomly arranged.

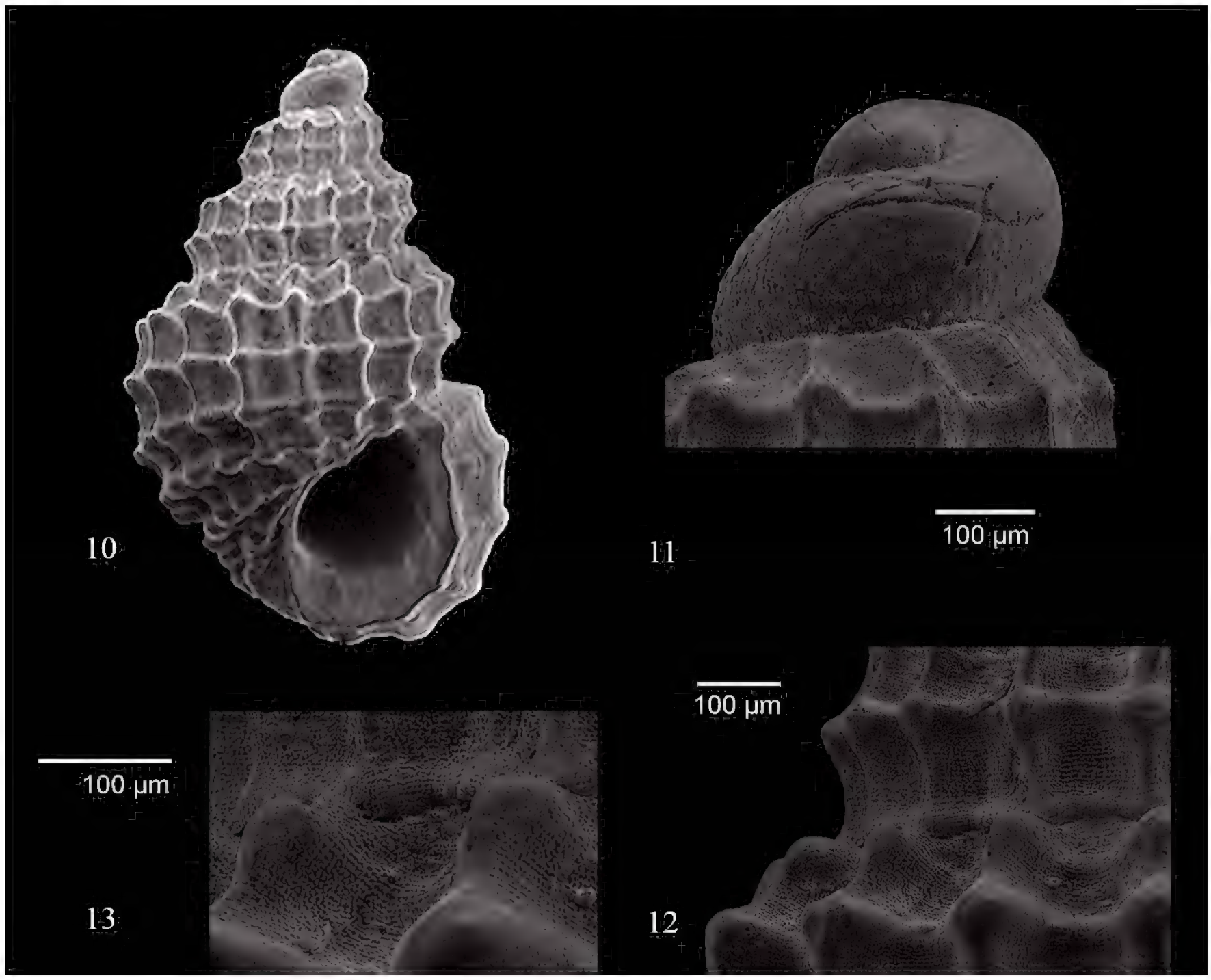
Alvania amatii (see Oliverio, 1986: 33, figs. 1–4; Oliverio & Amati, 1990: 85, tav. I, fig. 5; Giannuzzi-Savelli et al., 2002: 396, figs. 396, 397, 408a; Scaperrotta et al. 2012: 42, 5 unnumbered figs; Amati, 2014: 94, fig. 5D–E; Bitlis-Bakır & Öztürk, 2016: 448, tav. 2, fig. 9; Bitlis-Bakır & Öztürk, 2017: 6, figs. 2A–B) differs from *A. oetyliaca* n. sp. by the slender profile; number of spiral cords on the last whorl (7-8 v. 6), and above the aperture (3–4 v. 2); the protoconch with 4–5 spiral cords v. coarse tubercles randomly arranged.

Alvania nestaresi (see Oliverio & Amati, 1990: 85, tav. I, fig. 5, tav. II, figs. 6, 7; Giannuzzi-Savelli et al., 2002: 101, figs. 392, 395d; Gofas et al., 2011: 180, 3 unnumbered figs.; Scaperrotta et al., 2012: 51, 5 unnumbered figs.; Amati, 2014: 94, fig. 5A) differs from *A. oetyliaca* n. sp. by the more inflated profile; number of spiral cords on the last whorl (8–9 v. 6), and above the aperture (4 v. 2); the protoconch with fewer whorls (1.1–1.2 v. 1.25–1.3) and six spiral cords v. coarse tubercles randomly arranged.

Alvania balearica (Figs. 15, 16, see also Oliver



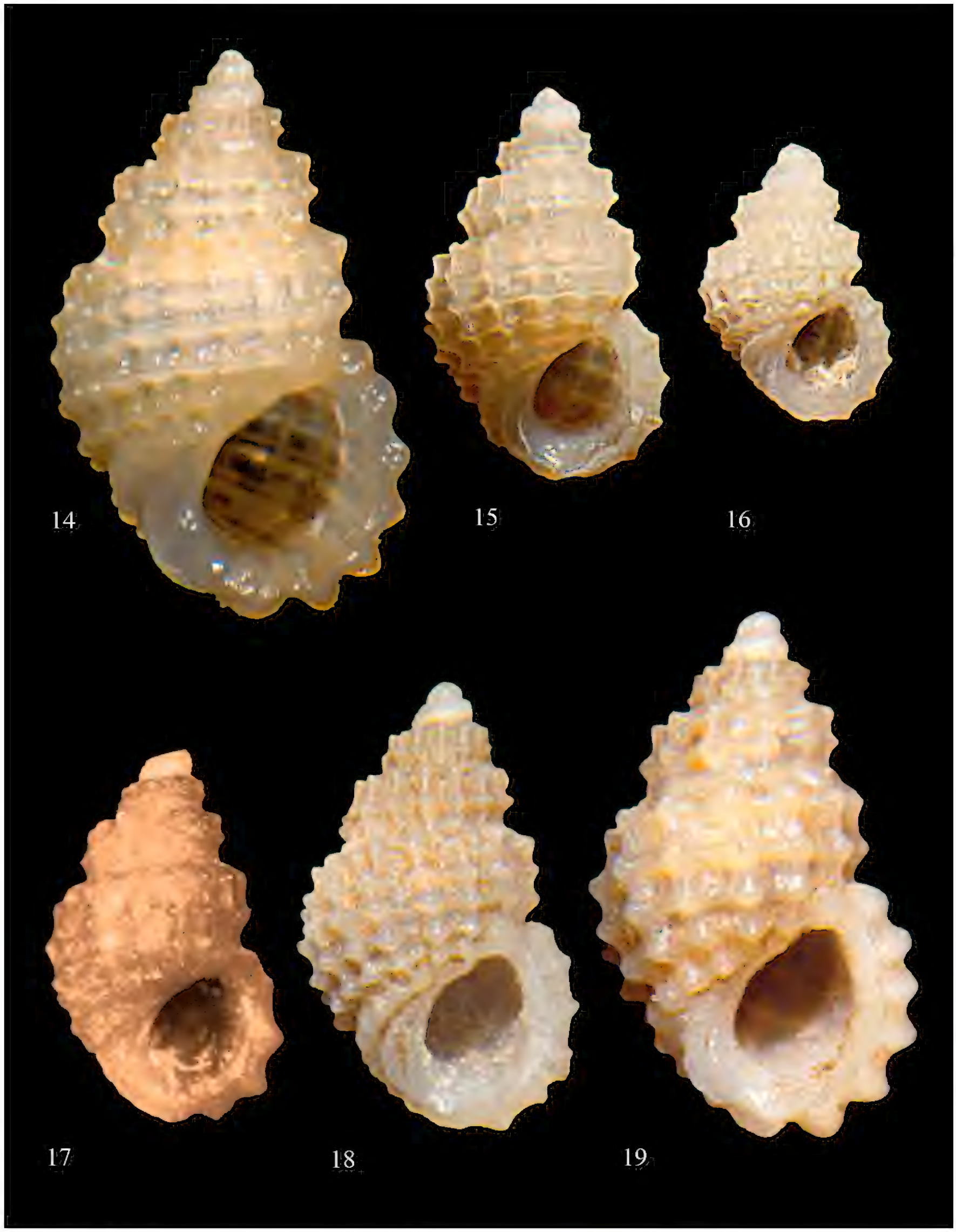
Figures 1–9. *Alvania oetyliaca* n. sp. from the type locality Itilo Bay, Peloponnese, Greece. Figs. 1–3: holotype, height 2.1 mm (MNHN IM-2000-33612). Figs. 4–6: paratype, height 2.1 mm (BA). Figs. 7–9: paratype, height 2.13 mm (SC).



Figures 10–13. *Alvania oetyliaca* n. sp. from type locality Itilo Bay, Peloponnese, Greece (MNHN IM-2000-33612). Fig. 10: holotype in apertural view, height 2.1 mm. Fig. 11: particular of protoconch. Figs. 12, 13: detail of the teleoconch microsculpture.

Teleoconch	1	2	3	4	Min-max	Mean
Height	2.1	2.1	2.13	2.16	2.1-2.16	2.12
Width	1.35	1.32	1.42	1.40	1.32-1.42	1.37
Aperture height	0.97	0.93	1.00	0.93	0.93-1.0	0.96
Height/Width ratio	1.555	1.590	1.500	1.543	1.500-1.590	1.55
Height/aperture height	2.165	2.258	2.130	2.322	2.130-2.322	2.22
N° of whorls	3.25	3.25	3.4	3.2	3.2-3.4	3.27
N° axial ribs on last whorls + varix	14+v	14+v	17+v	13+v	13-17+v	14.5
N°spiral cords on last whorls (above aperture)		6(2)	6(2)	6(2)	6(2)	6(2)
Protoconch	1	2	3	4	Min-max	Mean
Height	0.33	0.30	0.30	0.32	0.30-0.33	0.312
Diameter of nucleus	0.10	0.09	0.09	0.10	0.09-0.10	0.095
Diameter of first half whorl	0.21	0.20	0.20	0.23	0.20-0.23	0.21
Maximum diameter	0.32	0.33	0.30	0.33	0.30-0.33	0.32
N° of whorls	1.30	1.25	1.25	1.25	1.25-1.30	1.26

Table 1. Measurements of the teleoconch and protoconch of *Alvania oetyliaca* n. sp. in mm.
Numbers 1: holotype (MNHN IM-2000-33612); number 2: paratype (BA); numbers 3 and 4: paratypes (SC).



Figures 14–19. *Alvania* spp. Fig. 14: *Alvania cancellata* 'morpho minor' Madeira Island height 3.3 mm (MCZR). Fig. 15: *Alvania balearica*, Ibiza, Spain height 2.25 mm (JT). Fig. 16: *Alvania balearica* 'morpho minor' Ibiza, Spain height 1.62 mm (JT). Fig. 17: *Alvania sleursi*, holotype, S.ta Cruz de Flores -40 m, Azores Island height 2.15 mm (IRSN). Fig. 18: *Alvania subcrenulata*, Salina Island, Sicily, Italy height 2.6 mm (BA). Fig. 19. *Alvania hirta* Monterosato, 1884, Salina Island, Sicily, Italy height 3 mm (BA).

Figure 20. Map showing the type locality (A red) of the *Alvania oetyliaca* n. sp.

Teleoconch	5	6	7	8	9	10	Min-max
N° of whorls	3.75	3.5	3.5	3.5	3.3	3.25	3.25-3.75
N°axial ribs on last whorls + varix	14+v	16+v	13+v	16+v	14+v	14+v	13-17+v
N°spiral cords on last whorls (above aperture)	6(2)	6(2)	6(2)	6(2)	6(2)	6(2)	6(2)

Table 2. Measurements of the teleoconch of *Alvania oetyliaca* n. sp. Numbers 5–10: paratypes (SC).

& Templado, 2009: 59, figs. 1–7; Amati, 2014: 94, figs. 5B–C) has a very similar shell to that of *A. oetyliaca* n. sp.; it differs essentially in the protoconch with 3 principal spiral cords and tubercles v. coarse tubercles randomly arranged.

Alvania aliceae (see Amati, 2014: 89, 91, figs. 1A–C, 2A-D) differs from *A. oetyliaca* n. sp. by the slender profile; number of spiral cords on the last whorl (7–8 v. 6), and above the aperture (3–4 v. 2); the protoconch with 6–7 spiral cords v. coarse tubercles randomly arranged.

Alvania hirta (Fig. 19, see also Giannuzzi-Savelli et al., 2002: 103, fig. 399; Scaperrotta et al., 2011: 62, 5 unnumbered figures) differs from *A. oetyliaca* n. sp. by the slender and turricolated profile; more robust spiral cords with more protruding and acute tubercles at the intersection; the more thickened external varix with more prominent tubercles; the protoconch sculptured with micro granules arranged in dense spirals v. coarse tubercles randomly arranged.

Alvania cancellata (Fig. 14, see also Ponder,

Teleoconch	*Alvania subcrenulata*	*Alvania amatii*	*Alvania nestaresi*	*Alvania balearica*	*Alvania aliceae*	*Alvania oetyliaca* n. sp.
Height	2.45-3	1.8-2.5	1.85-2.9	1.6-2.5	2-05-2.8	2.1-2.41
Width	1.6-1.85	1.2-1.55	1.3-1.85	1.07-1.5	1.3-1.6	1.32-1.46
Aperture height	1.2-1.45	0.9-1.0	0.7-1.45	0.75-1.1	0.95-1.2	0.93-1.0
N° of whorls	3.1-3.7	2.7-3.5	2.7-3.7	2.5-3.7	3.1-4.0	3.2-3.4
Coloration	White with or without brownish bands	White with or without brownish bands	Whithis with brownish bands	White with or without brownish bands	White with or without brownish bands	White with or without brownish bands
Profile	Ovate-conical, with rather wide base	Ovate-conical tending to cylindrical	Ovate-conical tending to globular	Ovate-conical tending to turriculated	Ovate-conical, with moderate basal diameter tending to triangular	Ovate-conical, tending to subsquare-turriculated
N° axial ribs on last whorls + varix	13-14 + v	14-17 + v	14-19 + v	11-16 + v	13-15 + v	13-17 + v
N° spiral cords on last whorls above aperture	3-4	3-4	4	2-3 (4)	3-4	2
Spirals last whorls - base	4	4	4-5	4	4	4
Start of III spiral cord	1.2-1.8 whorls	1.3-1.7 whorls	1.5-2.1 whorls	1.5-2.2 whorls	1.8-3 whorls	absent
Start of I spiral cord	1.8-3 whorls	2-3 whorls	1-1.5 whorls	Only on the varix or absent	1.5-2.6 whorls	absent
Tubercles	Medium sized, from slightly to very pronounced	Medium sized, slightly pronounced	Large sized, rounded and slightly pronounced	Medium sized, very pronounced	Small sized, prominent, almost spiny	Small sized, slightly prominent, almost spiny
Protoconch	*Alvania subcrenulata*	*Alvania amatii*	*Alvania nestaresi*	*Alvania balearica*	*Alvania aliceae*	*Alvania oetyliaca* n. sp.
Height	0.27-0.38	0.30-0.32	0.25-0.30	0.30-0.35	0.30-0.35	0.30-0.33
Width	0.10-0.14	0.10-0.12	0.10-0.15	0.06-0.10	0.10-0.12	0.09-0.10
Diameter of first half whorl	0.20-0.22	0.23-0.25	0.20-0.25	0.20-0.25	0.20-0.25	0.20-0.23
Maximum diameter	0.32-0.38	0.35-0.40	0.32-0.37	0.325-0.375	0.35-0.40	0.30-0.33
N° of whorls	1.2-1.4	1-1.3	1.1-1.2	1.2-1.4	1.25-1.3	1.25-1.3
Sculpure	apical keel with tubercles	4-5 spiral cords	6 spiral cords	3 principal spiral cords	6-7 spiral cords	coarse tubercles

Table 3. Measurements of the teleoconch and the protoconch in Mediterranean species of the *Alvania subcrenulata* complex, in mm.

1985: 139, figs. A–C; Giannuzzi-Savelli et al., 2002: 102, figs. 398, 408b; Ávila, 2005: 268, 269, tav. III, figs. 1–12; Gofas, 2007: 790, figs. 5A–B; Garilli & Parrinello, 2010: 169, fig. G; Scaperrotta et al., 2011: 56, 5 unnumbered figs.; Gofas et al., 2011: 178, 3 unnumbered figs.; Bitlis-Bakır & Öztürk, 2016: 448, tav. 2, fig. 12; Bitlis-Bakır & Öztürk, 2017: 6, figs. 2I–J) differs from *A. oetyliaca* n. sp. by the larger size (H 3.1-5.0 mm v. H 2.1-2.41 mm); the multispiral protoconch v. paucispiral protoconch; and a visible columellar tubercle, absent in *A. oetyliaca* n. sp.

Alvania sleursi (Fig. 17, see also Amati, 1987: 30, figs. 1, 2; Gofas, 1990: 128, figs. 39–42; Ávila, 2005: 279, pl. VIII, figs. 1–12; de Frias Martins et al., 2009: 41, pl. IX, figs. 141, 142) has the shell very similar to that of *A. oetyliaca* n. sp.; it differs essentially for the twisted protoconch of 1.1–1.3 slightly convex whorls, with 5-6 evident spiral cords v. protoconch with a moderately twisted nucleus, sculptured by coarse tubercles randomly arranged.

Alvania laurae (see Brunetti & Vecchi, 2012: 45, figs. 3A–C; Brunetti & Vecchi, 2014: 116, tables 1c–d) of the Lower Pleistocene of Piacenza (Italy) has the shell very similar to that of *A. oetyliaca* n. sp. It differs in its convex outline v. subsquare outline with the first whorls turricolated in *A. oetyliaca* n. sp. The protoconch of *A. laurae* is initially sculptured by 5 fine cords, increasing to 9 on the last part v. sculpted by coarse tubercles arranged randomly; the protoconch of *A. laurae* is larger: number of whorls 1.2, diameter of nucleus 0.125 mm, diameter of first half whorl 0.275 mm, maximum diameter 0.4225 mm, height 0.368 mm (Brunetti & Vecchi, 2012) v. number of whorls 1.25–1.3, diameter of nucleus 0.09–0.10 mm, diameter of first half whorl 0.20–0.23 mm, maximum diameter 0.30–0.33 mm, height 0.30–0.33 mm in *Alvania oetyliaca* n. sp.

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The Balkan Terrapin *Mauremys rivulata* (Valenciennes in Bory de Saint-Vincent, 1833) (Testudines Geoemydidae) in the Aegean island of Chalki: native or introduced?

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ABSTRACT The presence of the Balkan Terrapin *Mauremys rivulata* (Valenciennes in Bory de Saint-Vincent, 1833) (Testudines Geoemydidae) for the Aegean island of Chalki (Dodecanese, Greece), is here recorded for the first time. *Mauremys rivulata* is common in continental Greece and quite widespread in many Aegean islands, however, its presence in Chalki, extremely dry island and poor of water resources, leads to important thoughts and questions.

KEY WORDS Balkan Terrapin; Chalki; Dodecanese; *Mauremys rivulata*; Rhodes Archipelago.

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INTRODUCTION

Mauremys rivulata (Valenciennes in Bory de Saint-Vincent, 1833) (Testudines Geoemydidae) is a medium-sized freshwater turtle. Shell size reaches a straight carapace length of up to 244 mm in females, and up to 187 mm in the slightly smaller males (Rifai & Amr, 2004; Mantziou, 2006). Males usually have a longer post-anal tail length, and the base of the tail is wider than that of females. Males have a generally flatter appearance than females and their plastron is slightly concave (Wischuf & Busack, 2001; Rifai & Amr, 2004). The carapace of adults is usually uniformly brown, or olive green to green, with faint or no pattern. The plastron of adults rarely has light shapes; however, with age the plastron lightens up and appears more yellowish overall. The bridge is generally uniformly dark to black, sometimes light yellow spots can be seen on its margins (Wischuf & Busack, 2001; Mantziou & Rifai, 2014). *Mauremys rivulata* occurs in a variety of natural and man-made habitats from streams to seasonal ponds, lakes, brackish coastal lagoons and drainage ditches, irrigation canals, dams and reservoirs. Also is highly tolerant of a wide range of water conditions; it is found in acid, alkaline, and several polluted and brackish water bodies (Gasith & Sidis, 1983; Sidis & Gasith, 1985) and it has a great tolerance to seawater, wide sea straits and sea bays (Mantziou & Rifai, 2014). This species ranges from coastal Croatia, Bosnia-Herzegovina, Montenegro and Albania, through most of Greece (including many Aegean and Ionian islands), southeastern Macedonia and southern Bulgaria, to the Marmara Sea region, and widely through the Mediterranean regions and river basins of Turkey to western Syria, Lebanon, northwestern Jordan and northern and central Israel (Van Dijk et al., 2004).

This taxon is widely treated as a subspecies of *Mauremys caspica*, but has most recently been considered a full species. In the taxonomic study of the genus *Mauremys* Gray, 1869, Fritz & Wischuf

(1997) recognized that there is a clear geographical partition between *M. caspica caspica* and *M. caspica rivulata*; morphometrics features could not separate the two subspecies, but they suggested species status on the basis of the geographic separation and the color pattern of the carapace and plastron. The elevation of *M. rivulata* to species level was later confirmed by molecular data, using both mitochondrial DNA and nuclear markers (Mantziou et al., 2004; Barth et al., 2004; Mantziou, 2006; Fritz et al., 2008).

MATERIAL AND METHODS

Study area

Chalki is a small island belonging to the Dodecanese Archipelago (SE Aegean), located southwest of Rhodes Island. Its coordinates are: 36°13'44.49"N; 27°34'18.74"E. Administratively Chalki is part of Rhodes Regional Unit. It's located west of Rhodes (Monolithos Cape), from which is only five nautical miles, south-east of Tilos (10 nautical miles), and north of Karpathos. Has a length of 10 km, a width of 4 km and an area of 28.125 km^2. The wider and more important bays are Imborios and Pondamos (Iliadis, 1950). Chalki is a mountainous and rocky island and the highest peak is represented by Maistros Mount (593 m a.s.l.). The entire island, except for the eastern part, is surrounded by very steep cliffs with scarce accessibility. These vertical cliffs allowed the presence of a rare and highly specialized chasmophytic flora. Several species are endemic with a distribution area limited to the island and to the SE Aegean, including W Turkey (Cattaneo & Grano, 2014; Cattaneo & Grano, 2015). Recently it has been discovered a new species for science, that seems to be restricted to Chalki and the nearby island of Tilos: *Seseli halkensis* Cattaneo, Tan et Biel (Cattaneo et al., 2016). The island is essentially dry, and lacks of superficial hydrography, however, the numerous wells on the island are still rich in water. In ancient times Chorio (the current Palio Chorio) was the capital, village by now abandoned. Currently the population, which amounts about three hundred inhabitants, is concentrated exclusively in Imborios, which appears to be the only village on the island. Together with the small surrounding islands, Chalki is included in the Natura 2000 network (GR 4210026) for the presence of particular bird species and for a peculiar chasmophytic flora related to elective habitats represented by crevices in the limestone rocks of these islands (Cattaneo & Grano, 2014; Cattaneo & Grano, 2015).

Methods

The island of Chalki has been studied by the authors in four different times, during August 2014, April 2015, August 2016 and August 2017. The first investigations were also extended to the neighboring island of Alimia (Grano et al., 2015). During the fourth investigation of the island, on August 17th in the bay of Dhio Ghiali, a recently died specimen of *M. rivulata* was found (Fig. 1). The Dhio Ghiali's bay, accessible only by sea, has been formed by the estuary of an ancient far-reaching river currently dry. Inside this bay, close to the beach, there is a well used for watering the goats, but actually dry; the dead specimen was found in close proximity of this well (Fig. 2). The well was built from stones and has a degrading part to allow the animals to drink directly. Such a structure could have allowed the specimens of *M. rivulata* to get in or out. The shell, which was in excellent condition with the plaques well attached to the carapace, has the following features: CL (greatest carapace straight length) 18.00 cm; CCL (greatest curvilinear carapace length) 20.80 cm; CH (carapace height) 6.90 cm; PL (greatest plastron length) 17.30 cm; CW1 (medial carapace width) 12.50 cm; CW2 (greatest carapace width) 12.90 cm; W (weight) 244 g. The shape and size are compatible with a female specimen. Fieldwork and lab measurements were conducted in accordance with the Greek National Legislation (Presidential Decree 67/81).

RESULTS AND CONCLUSIONS

The first data about the herpetofauna of Chalki were provided by Boettger (1888) and Werner (1935), afterwards summarized in the checklists on the Greek herpetofauna realized by Chondropoulos (1986, 1989). Later the island was once again investigated by Buttle (1995) and by Cattaneo (2009). Only five species were known for the island: *Hemidactylus turcicus* (Linnaeus, 1758), *Cyrtopodion*

Figure 1. The died *Mauremys rivulata* (Chalki island, Dodecanese Archipelago, SE Aegean).

Figure 2. The well in Dhio Ghiali's bay (Chalki island, Dodecanese Archipelago, SE Aegean).

kotschyi (Steindachner, 1870), *Stellagama stellio daani* (Beutler et Frör, 1980), *Ablepharus kitaibelii* (Bibron et Bory, 1833), *Dolichophis jugularis zinneri* Cattaneo, 2012. Boettger (1888), on report by Oertzen, had made a reference for the island of Chalki to the existence of *Montivipera xanthina* (Gray, 1849), but the presence of this viper has never been validated by any authors (Dimaki, 2002). In 2015, the authors confirmed the presence of another snake: *Zamenis situla* (Linnaeus, 1758) (Grano & Cattaneo, 2015). The discovery of this snake, species related to adequately damp environments, highlighted the presence of some humid areas on the island. This latest discovery shows that there is still to be investigated on the island. It is to be considered that Chalki is very hard to investigate since the presence of only one viable road, the absence of trails, and transport services, moreover, many areas (including Dhio Ghiali) can be reached only by sea. The presence of *M. rivulata* on Chalki, although anomalous, is compatible with its features as: the Balkan terrapin is still widely distributed in the Aegean (Bader et al., 2009); on most medium-sized island, only small population of this species are to be found (Broggi, 2012); this species is able to colonize artificial reservoirs created in the island (Broggi, 2012); the preferred habitats of this species are the estuaries of streams and river (Broggi, 2012).

It is also reasonable to think that this unique specimen of Balkan terrapin has been subjected to passive transport, but the area in question is not frequented by man (only by a few tourists with boats during the summer). Or it might have come from the sea already dead, but its perfect conditions (it seemed dead from short time) and the absence of incrustations are not compatible with a prolonged permanence in the sea.

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The Wolf, *Canis lupus* Linnaeus, 1758 (Mammalia Canidae): re-colonization is still ongoing in Southern Italy: a breeding pack documented through camera traps in the Salento Peninsula

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ABSTRACT

The authors report the presence of the wolf in the Salento Peninsula (southern Apulia) after more than a century of the absence of sightings. New data for this area resulted from the analysis of video-photographic material provided by various collaborators (referring to the three-year period 2014-2017), as well as from camera trapping activities carried out by the authors in 2017 which revealed the presence of a breeding pack. These data help to update our knowledge of the presence of the wolf in Apulia and they extend the distribution range of the species ca. 100 km southward, making this area the extreme eastern limit of the Italian populations. The investigations were also part of a project commissioned to the authors by the "Costa Otranto Leuca e Bosco di Tricase" Regional Natural Park in March 2016, whose subject was "A preliminary study of wildlife or stray animals potentially harmful to crops and breeding stocks in the Protected Area".

KEY WORDS *Canis lupus*; Distribution; Wolf; Puglia; Salento.

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INTRODUCTION

Up to the middle of the 19th century, the wolf was widely distributed throughout Italy, with the exception of Sardinia and the small islands where it was never present (Cagnolaro et al., 1974). At the beginning of the 20th century, the increasing human pressure due to the exploitation of natural resources deprived the wolf of important refuge areas and natural prey. Moreover, continued persecution by man caused a steady, progressive population decline that led to the disappearance of the species from the entire Alpine arc in the early 20th century and then from Sicily in 1935. Until the 1950s, the presence of wolves continued to be recorded in most of the Apennine chain, but in subsequent years there was a rapid decline. The Italian wolf population reached its historical minimum in the 1970s, when the number of individuals was estimated at close to 100 (Boitani & Zimen, 1975).

There was a process of expansion in subsequent years thanks to a series of historical, ecological, environmental and legal factors (Boscagli, 1991; Aloise et al., 2017). The end of the 1980s saw the first recorded presence of the wolf in the pre-Alps,

indicating the beginning of recolonization of the Alps by means of natural dispersion of the Apennine population (Fabbri et al., 2007).

At present the wolf is stable in the Western Alps and to a lesser extent in the central-eastern part of the Alps where there are records of stable wolf pairs coming from both the Italian population and the Dinaric and Carpathian ones (WAG, 2014). In the rest of the Italian Peninsula, sporadic sightings have increasingly been recorded in medium and low hill zones. In spring 2017 the presence of the wolf was also documented in the Ticino Park in Lombardy, where there had been no sightings since the Middle Ages.

Regarding the presence of the wolf in Apulia, the official data updated to 2016 (Gaudiano et al., 2016) indicate that the species is distributed over ca. 30% of the regional territory, including all of the north-west part, the Murge plateau and the ravines of the Ionian arc; the data also show the presence of nuclear families in the area of the Gargano National Park and Alta Murgia National Park.

The latest records of the wolf in Salento date to the 19th century (Costa, 1871). The presence in this area is documented since prehistory not only by numerous skeletal remains from archaeological sites (Grotta Romanelli, Castro (Lecce)) (Tagliacozzo, 2003), but also by necklace pendants made of wolf teeth in the metal ages (Grotta dei Cervi Badisco, Otranto (Lecce); Roca, Melendugno (Lecce) (Rugge, 2015). Other sporadic skeletal remains from that period have been found at numerous sites (Cavallino (Lecce); Roca, Melendugno (Lecce); Egnazia, Fasano (Brindisi); Torre Guaceto (Brindisi) (Wilkens, 1998). Moreover, various stone artefacts in the territory, such as traps excavated in the rock at "Terenzano" near Ugento (Lecce) and "anti-wolf" walls for the protection of flocks inside the courtyards of farms, testify both to the presence of the wolf and to an already conflictual relationship with the species. Indeed, "rewards" for wolf kills were offered in 1400 (Ferrante Gravili, 2012), the amount varying according to the weapon used. At the end of the 18th century, Costa (1871), in "Fauna Salentina", considered the wolf: "*not rare in the mountainous and wooded localities of the province, from where it readily descends into the plains, not lacking in these lands in which it has been seen to approach and even enter the village.*"

MATERIAL AND METHODS

The investigations were also part of a project commissioned from the authors by the "Costa Otranto Leuca e Bosco di Tricase" Regional Natural Park in March 2016, whose subject was "A preliminary study of wildlife or stray animals potentially harmful to crops and breeding stocks in the Protected Area". The sightings reported herein refer to video-photographic material from various sources collected over one year of research and from camera trapping carried out by the authors in spring-summer 2017. Analysis of the material was conducted in particular by two of the authors (GG and FC), qualified operators according to the wolf monitoring guidelines (Ciucci et al., 2002) and as codified in other protocols (Kaczensky, 2009; Marucco et al., 2014). After the analysis of the images, field inspections were carried out to determine the environmental context of the films/photographs and also to validate their authenticity. In this phase of the study, it was also possible to set up five camera traps, appropriately positioned in the areas considered most suitable to verify the presence of breeding packs. For the data analysis we used the information layers made available by the Regional Information System (SIT) of the Apulia Region, processed in digital form with QGIS software; further thematic cartography of the area was also consulted (Lavarra et al., 2014). To maintain homogeneity of the information, the wolf distribution is represented on a grid with 10 x 10 km cells according to the European standard.

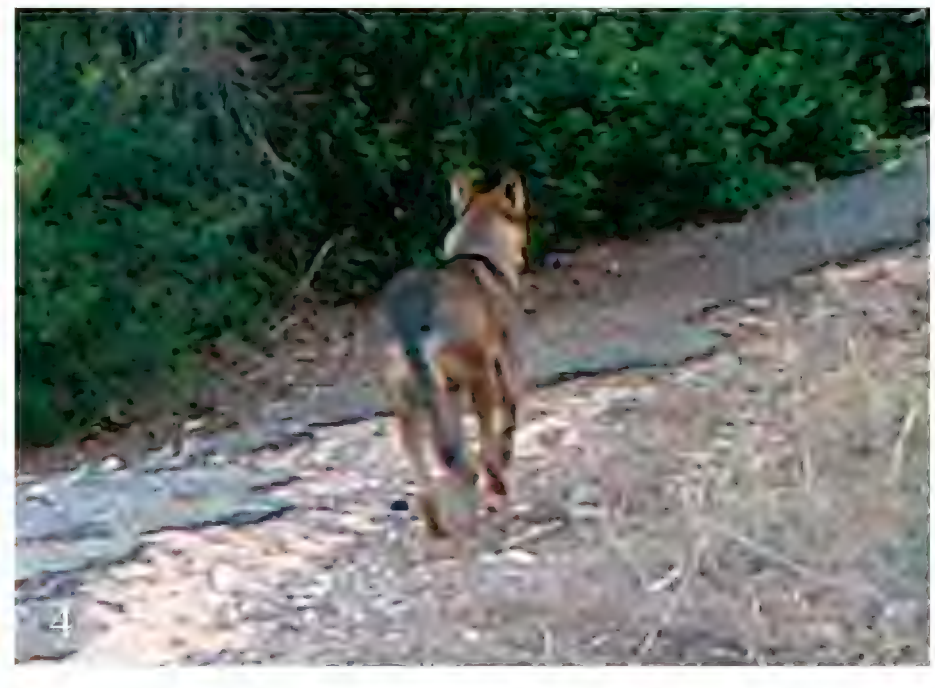
RESULTS

Table 1 schematically reports the data of the images provided to the authors, with indication of the date, environmental context and type of event observed.

The films and photographs show single individuals (Figs. 1, 2), for which it was possible to identify the sex in only one case. No specimens with abnormal phenotypic characteristics or any diagnostic elements useful for subsequent individual recognition were detected. However, in some cases the location and dates of the sightings suggest the presence of different individuals.

Date	Environmental context	Type of event
December 2015	Pseudosteppe	Predation on a domestic animal (film)
December 2016	Olive grove	Crossing an unpaved path in an olive grove (film)
April 2016	Olive grove	Passage of a male wolf in an olive grove at the edge of an unpaved path (film)
May 2017	Vineyard	Passage of a wolf in a vineyard at the edge of an unpaved path (film)
September 2016	Uncultivated land	Wolf on the edge of a quarry (photograph)
September 2016	Garrigue	Wolf on the edge of shrubland (photograph)

Table 1. Analysed video-photographic material from various sources.



Figures 1, 2. Photograms from some of the analysed videos. Figures 3, 4. Camera trapping results (spring/summer 2017).

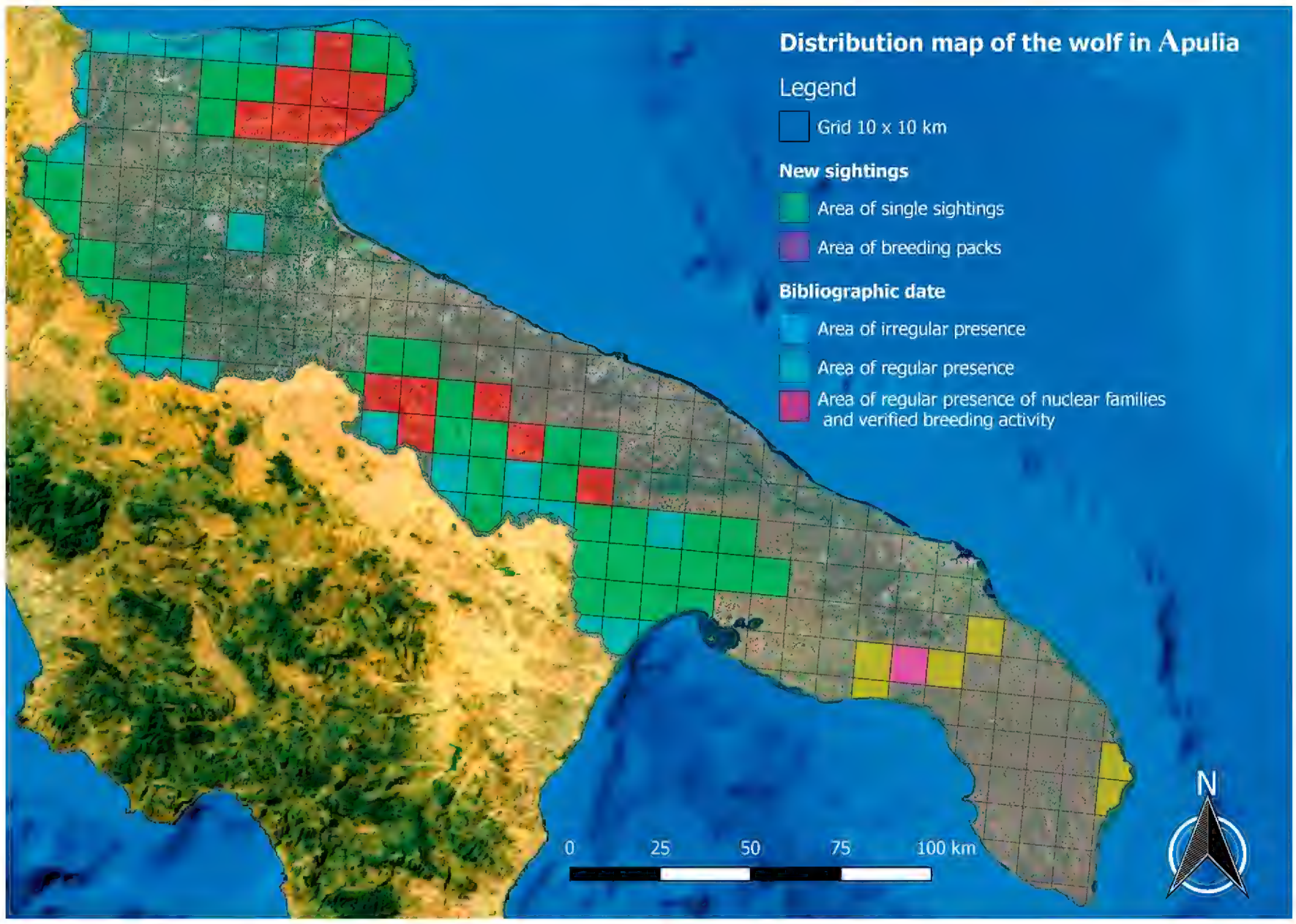


Figure 5. Updated distribution of the wolf in Apulia.

All the images refer to agro-ecosystems, a typology which together with urban centres accounts for almost 80% of the regional territory.

The camera traps set up in spring-summer 2017 yielded a positive result in one case, recording the presence of at least one first-year pup and two adult individuals, of which one a male (Figs. 3, 4); this attests to the stable presence of the species in the area.

The new findings extend the distribution range of the species in Apulia ca. 100 km southward, making this area the extreme eastern limit of the Italian populations. Figure 5 shows the distribution of the wolf in Apulia in the light of the present sightings. The bibliographic data are from Gaudiano et al. (2016).

CONCLUSIONS

The reported data are the first evidence of the presence of the wolf in the Salento Peninsula after more than a century of the absence of sightings. In addition to the verified presence of single individuals in various parts of Salento, probably due to natural dispersion of the species, the identification of a breeding pack indicates a certain degree of territorial stability and the effective return of the species to the area. Besides being part of the wider context of the wolf distribution dynamics in Italy, this finding is particularly important in light of the territorial marginality of Salento with respect to the known distribution range and it confirms the presence of the species even in areas considered not ecologically ideal. The phenomenon can be attributed to the natural expansion of the population, which in recent years has recolonized medium and low hill zones and has even moved close to large cities and into areas recently considered not particularly suitable. In Salento, the environmental context of the sightings and the potential areas of connection with already known

stable populations in the rest of Apulia are heavily influenced by human activities. In this regard, the presence of the wolf is of significant management interest in view of the potential implications for animal husbandry. The ongoing recolonization by the wolf is further fuelled by the scarcity of natural prey in the area south of Lecce and this brings the risk of increasing conflict with local breeders. Therefore, it would be advisable to monitor the process in order to assess the real impact on animal husbandry activities, to evaluate possible hybridization events and to conduct correct, efficacious management and conservation of the species.

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Contribution to the knowledge of sicilian spider fauna (Arachnida Araneae)

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ABSTRACT In the present paper are reported new spiders from Sicily (Aranea). Additional biological and taxonomic notes are provided.

KEY WORDS Araneae; new data; first records; Sicily.

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INTRODUCTION

In Italy 1632 species of spiders are currently reported, divided in 429 genera and 54 families (Pantini & Isaia, 2017); of these, 403 species are reported for Sicily, divided in 186 genera and 42 families (see also van Helsdingen, 2010 and World Spider Catalog, 2017).

The present paper reports on two species of spiders, new for Sicily, as a result of field work carried out on the sicilian spider fauna in the last years.

MATERIAL AND METHODS

All samples were collected by sight on the soil, on plants or under the rocks. Observations on ecology of these organisms were made directly in the field.

The samples, taken in laboratory, were treated with ethyl acetate and then observed with binoculars. They were photographed with a Nikon d90 reflex and a macro lens of 100 mm for identification.

The specimens were stored in centrifuge tubes of different sizes, depending on the size of the sample, and were fixed in 75% ethanol.

Voucher specimens are stored in the author's collection and were collected by the same author. Each locality and/or collection site is in the original language (Italian).

The classification, taxonomic order and nomenclatural arrangement follow Roberts (1995), Trotta (2004) and Pantini & Isaia (2017). For each species, literature, chorotype, regional distribution and habitats are indicated.

RESULTS

Systematics

Ordo ARANEAE Clerck, 1757
Familia ARANEIDAE Clerck, 1757
genus *Lipocrea* Thorell, 1878

Lipocrea epeiroides (O. Pickard-Cambridge, 1872)

EXAMINED MATERIAL. Sicily, Palermo, Monreale: Caculla, 05.IX.2017, 2 females; idem, 10.IX.2017.

DISTRIBUTION AND BIOLOGY. Sardinia, Greece, Cyprus, Turkey, Israel, Yemen, India. This species

Figures 1–5. *Lipocrea epeiroides* from Caculla (Sicily, Palermo, Monreale). Fig. 1: *Lipocrea epeiroides* in the natural habitat. Fig. 2: *Lipocrea epeiroides* male. Fig. 3: *Lipocrea epeiroides* female. Fig. 4: Particular of epigynum, external genital structure of female. Fig. 5: Cocoon of *Lipocrea epeiroides.*

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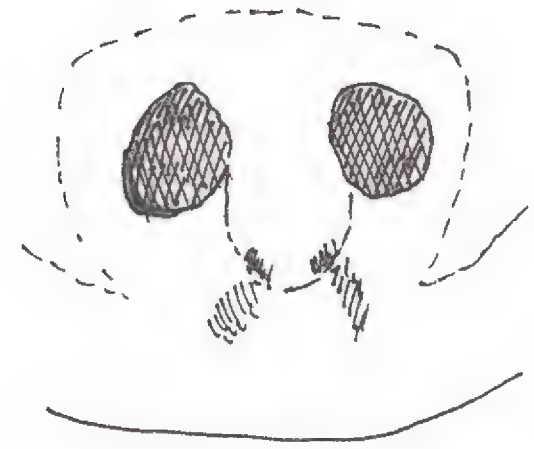

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Figures 6, 7. *Ozyptila confluens* from Caculla (Sicily, Palermo, Monreale). Fig. 6: *Ozyptila confluens*. Fig. 7: Particular of epigynum.

has been described for the first time in Israel (Pickard-Cambridge, 1872), rediscovered in Israel (Levy, 1986), subsequently reported inYemen (Grasshoff & van Harten, 2007), Turkey (Kunt et al., 2010), Greece (Wunderlich, 2011), central India (Keswani & Vankhede, 2013), Sardinia (Bosman & Colombo, 2015).

The two sicilian specimens were found and caught in their webs, during the night (see also Bosman & Colombo, 2015); the collection area was a riparian area close to the banks of the Sant'Elia River, upper course of the Oreto River; the partially anthropic area has olive trees, *Prunus* sp., *Juglans regia* L., *Populus* sp., *Salix* sp., and spontaneous vegetation typical of the river areas in northwest Sicily: *Rubus* sp., *Arundo donax* L., *Borago officinalis* L., etc.

Several specimens have been observed, webs of about 40 cm in circumference were at low altitudes, on average 30–40 cm from the ground and always very close to the banks of the river. The specimens occupied the center of their web while waiting for a prey, and if they were touched with a stronger vibration, they dropped down from the web, abandoning it. Although I did a lot of research, I've never seen specimens during the day. Moreover, the first speciment, which I bred for a while, spent the day off and idle, which makes me suppose that this is a purely night-time species. On 06.IX.2017 eggs were laid in a sample cocoon, no longer cared for, which was stored in a damp environment; when the cocoon was opened, on 26.IX.2017, it showed 10 spiderlings.

Familia THOMISIDAE Sundevall, 1833
Subfamilia Thomisinae Sundevall, 1833
Tribù Diaeini Sundevall, 1833
genus *Ozyptila* Simon, 1864

Ozyptila confluens (C.L. Koch, 1845)

EXAMINED MATERIAL. Sicily, Palermo, Monreale: Caculla, 08.IV.2017, 2 females; idem, 10.IX.2017.

DISTRIBUTION AND BIOLOGY. Southern Europe, Syria. Italy: Tuscany (de Dalmas, 1922); Umbria (di Caporiacco, 1950); Apulia (di Caporiacco, 1953); Lazio (di Caporiacco & Denis, 1954); Sardinia (Kraus, 1955; Pavesi, 1876 sub *Oxyptila guttulata* n. sp.; Garneri, 1902 sub *Oxyptila grata*; Trotta, 2009, 2011; Pantini & Sassu, 2009; Pantini et al., 2013); Emilia-Romagna (Zangheri, 1966); Liguria (Thaler & Zapparoli, 1993; Trotta, 2007); Campania (Trotta, 2007).

Habitat (see Pantini et al., 2013): Cherry-orchard, garrigue, hazelnut-orchard, walnut-orchard, minning landfills covered by pioneer plants. A sicilian specimen was found under a bird carcase in advanced state of decomposition,

REMARKS. The genus *Ozyptila* is morphologically similar to the genus *Xysticus* C.L. Koch, 1835, but it is different from the latter by the disposition of the median eyes, that are disposed in a square slightly wider than long and by the presence of clabbing bristles. Within the *Ozyptila* genus genital organs are extermely useful to distinguish the species.

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Ropalopus boreki n. sp. from Peloponnese, South Greece (Coleoptera Cerambycidae Callidiini)

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ABSTRACT In this paper is described a new species of *Ropalopus* Mulsant, 1839 from Peloponnese (South Greece) closely related with *Ropalopus siculus* Stierlin, 1864 from Sicily and already known from Greece (Larisa, Ossa Mt.).

KEY WORDS Coleoptera; Cerambycidae; *Ropalopus*; new species; Greece.

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INTRODUCTION

Studying part of the Cerambycidae collected by my friend and colleague Robert Borek (Aeropolis, Greece) I found several specimens belonging to genus *Ropalopus* Mulsant, 1839 that, after deeper study, appear to belong to an unknown species. The new species is clearly close to *R. siculus* Stierlin, 1864 from Sicily and already known from Greece (Larisa, Ossa Mt.) but easy to distinguish from it according the characters indicated in this paper.

RESULTS

Systematics

Ordo COLEOPTERA
Familia CERAMBYCIDAE
Subfamilia CERAMBYCINAE Latreille, 1802
Tribus CALLIDIINI Mulsant, 1839
Genus *Ropalopus* Mulsant, 1839

Ropalopus boreki n. sp.

TYPE MATERIAL. Holotypus male, Greece: Peloponnese, Lakonia, Neo Itilo, Itilo reg. Avramniaka, 15-25.VI.2017, sugar traps, Robert Borek legit. (Pierpaolo Rapuzzi collection); paratypes: 5 males and 3 females, same data of holotype, Robert Borek collection (Aeropolis, Greece) and Pierpaolo Rapuzzi collection; 1 female, Greece: Peloponnese, 5 km south from Stoupa, 21.VI.1996, M. Egger legit/collection (Wattens, Austria).

DESCRIPTION OF THE HOLOTYPUS. Length 22.0 mm, width 10 mm. Body black, shining, elytra with metallic reflex. Head small, heavy punctured with a deep carina between the eyes, antennal tubercles small, moderately flat and impunctate on the apex. The pubescence is made by short and dark brown sparse setae, only close to the labium the pubescence is denser and longer. Head insert deep inside the pronotum that is evidently wider than the head. Pronotum large little larger than longer, hexagonal, deep punctured. The points are denser and smaller at the sides and on the disk, there is a hexagonal area vermiculate with very deep points fused one with the others. Sides of pronotum angulate the largest in the middle. The pubescence on pronotum is made by sparse (sparser than on the head) short black erect hairs. Scutellum

Figure 1. *Ropalopus boreki* n. sp. holotype male. Figure 2. *Ropalopus boreki* n. sp. paratype female.

black, rectangular with several deep points on its surface. Elytra long, flat, evidently enlarged toward the apex. The first half of the elytral length is evidently metallic, golden-green, otherwise in the second half this reflection is less evident, due to the very dense punctuation. The sculpture on the first half of elytra is made by vermiculate points made by the fusion of single points. The space between each point is very shining. Moving from the shoulders to the apex these points become denser and less deep, the space between each point becomes mat due to the micro-sculpture. In this way, the second half of elytra is mat and the metallic reflex is less evident. Elytral apex rounded. Antennae of the same length of the body, blackish-brown with dense isolated points except for the apex that is shortly impunctate. Inner side of antennae with dense, short, stout, erect setae. Antennal segments from the third to the eighth with a long tooth on the inner side, segments nine and ten with a short tooth in the same position. Legs long, strong, black, quite impunctate with sparse erect black setae. Fore tibiae little arcuate, the others straight.

VARIABILITY. The paratypes are quite homogeneous, the body shape of the females is larger as in other species of the genus *Ropalopus*. The color is the same of the Holotype for all the specimens. The length range is, for the males, between 23 to 34 mm and for the females between 23 and 29 mm.

ETYMOLOGY. I dedicate the new species to Robert Borek from Areopolis (Greece) as thanksgiving to give me the opportunity to study part of his specimens for study.

DISTRIBUTION AND BIOLOGY. This new species is known, at moment, only from Greece (Peloponnese).

The biology of *Ropalopus boreki* n.sp. is unknown. All the specimens were collected using sugar traps hanged on *Acer* trees. It is very likely that this plant is the host of the new species. Moreover all the other species from the same group live only on *Acer*.

REMARKS. The new species is related with *R. siculus* described from Sicily (Italy) (Löbl & Smetana, 2010) and recently discovered in Greece (Ossa mountain, Dutru & Le Restif, 2002: 36) but it is easy to distinguish according to the different elytral sculpture made by deeper and larger points on the basal half, the thinner and denser points on the second half of the elytral length, moreover this area has a "mat aspect" due to the micro-sculpture between the single points. In *R. siculus* this sculpture is not so evidently separated and there is a gradual changing in deep and density of the points. In *R. boreki* n. sp. the pronotum is wider, quite as large as wide in *R. siculus*. The points on pronotum of *R. siculus* are never vermiculate in the middle but in the middle close to the base of both the sexes there is a more or less small shining area that is totally missing in the new species and it is substituted by vermiculation. Moreover, all the points are denser and less regular in *R. boreki* n. sp. than in *R. siculus*. The antennae are shorter in the new species in both the sexes. The color is normally green with golden reflex in the new species and more reddish-green in *R. siculus*.

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